DIV. OF HERPETOLOGY

1959, No. 1 April 1

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FUTURE MEETINGS: The American Society of Ichthyologists and Herpetologists will meet on the campus of San Diego State College, San Diego, California, from June 17 to June 21, 1959, inclusive. The sessions will be held concurrently with the meetings of the Western Division of AAAS. Next year the Society will meet at the Chicago Natural History Museum from June 27 to June 29, 1960.

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1959 No. 1 COPEIA April 17

Distribution and Differentiation of the North Pacific Myctophid Fish, *Tarletonbeania taylori*[1]

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ROBERT L. WISNER

TARLETONBEANIA TAYLORI MEAD (1953) was described from six specimens collected near the northeastern shore of Honshu Island, Japan. It differs from its transpacific congener, *T. crenularis* (Jordan and Gilbert), the only other known species of the genus, primarily in that the caudal peduncle of the male bears an infracaudal as well as a supracaudal luminous gland. The females of both species bear neither gland.

During the latter part of 1953, when the Scripps Institution of Oceanography, with the support of the Office of Naval Research, conducted the Trans-Pacific Expedition across the northern Pacific and into the south-central part of Bering Sea, specimens of *T. taylori* were taken from the extreme northern areas of the Pacific but not from Bering Sea. The collections of *T. taylori* from the northeastern Pacific were later augmented by other agencies. I have studied the series of specimens now available from each area, with particular reference to meristic variation.

ACKNOWLEDGMENTS

Grateful appreciation is extended to the several members of the Trans-Pacific Expedition for aid in the collection of specimens. In particular I thank Donald E. Powell, formerly Chief of the North Pacific Fisheries Exploration and Gear Research, Seattle, Washington, and Garth I. Murphy, Director of Pacific Oceanic Fisheries Investigations, Honolulu, Hawaii, both of the U.S. Fish and Wildlife Service, for making available specimens from the northeastern Pacific. Paratypes of *T. taylori*, USNM 164971 and 164972, were loaned by the United States National Museum through the kindness of Leonard P. Schultz, Curator of Fishes.

METHODS

The vertebral centra were counted from X-ray plates. The hypural plate was included in the count. Fin rays were counted after the method of Hubbs and Lagler (1947). The photophore terminology follows that of Bolin (1939). The counts are combined for each area because few samples contained a sufficient number of specimens to provide statistical reliability.

Because the overlap between the two species in meristic counts is very considerable, precautions were taken to assure that the specimens without caudal luminous glands were assigned to the proper species. This was done by comparing the meristics of the group involved with data from specimens having caudal glands. In all samples except one, which is elaborated upon in the discussion, all evidence indicates that there was no mixture of species.

The meristic data are graphically analyzed following the method proposed by Hubbs and Hubbs (1953). In each bar the base line represents the extremes of range; the short, vertical line represents the mean value; the solid portion represents two standard errors of the mean plotted on each side of the mean; and the open, or outlined portion, one standard deviation plotted on each side of the mean.

Morphometric data disclosed little of value and are not given.

GEOGRAPHICAL VARIATION OF *Tarletonbeania taylori*

Within the range of *Tarletonbeania taylori*, as defined by the development of an infracaudal luminous gland, considerable difference is evident between the series from the northwestern and the northeastern Pacific in certain meristic characters, particularly in the number of vertebrae, in the total number of photophores in the anal series, and in the number of anal rays (Figs. 2–8). For both the posterior series (AOp) and the total anal photophores (AO) the data (Figs. 2 and 3, Table I) indicate the virtual certainty that the two areas do not comprise a homogeneous population. The indicated probability of significance is about 2.5×10^8:1. The data for the anterior anal series (AOa) in contrast, indicate about one chance in ten that the two groups are homogeneous (Fig. 4, Table I).

[1] Contributions from the Scripps Institution of Oceanography, New Series.

The difference between means for vertebral centra (Fig. 5, Table II) is also of a high order of significance, the odds being slightly over 1.6×10^4:1 against the two populations being homogeneous.

The difference between means for numbers of gill rakers (Table IV) shows relatively little significance as compared to the previous meristic characters, the odds being 20 to 1 in favor of heterogeneity. The mean number of upper rakers for *T. taylori* from the northwestern Pacific is actually 5 rather than 6 as listed by Mead (1953). However, the total range of counts, as given by Mead, is confirmed.

The differences between means for both the dorsal and pectoral fin rays (Figs. 6 and 7, Table III) indicate low levels of significance, the respective odds being 10 and 6 to one that the two populations are heterogeneous. However, the means for anal rays (Fig. 8, Table III) indicate odds of about 400 to 1 in favor of heterogeneity.

The degree of differentiation indicated for several characters and the apparent clines shown by Figures 2–8 involving *T. crenularis* and the two forms of *T. taylori* immediately suggest speciation at the subspecific level. However, the luminous-gland character, as indicated below, indicates specific separation. The test of Co-efficient of Difference, as described by Mayr, Linsley, and Usinger (1953), was applied to the two characters (total anal photophores and vertebrae) showing the most pronounced difference between the northwestern and northeastern populations of *T. taylori*. The results indicate that in regard to nonoverlap in characters too few individuals could be separated from each population to warrant subspecific separation. The same conclusion stems from a visual inspection of the graphs, according to the criteria presented by Hubbs and Hubbs (1953). However, in most meristic characters, the difference between the two forms of *T. taylori* equal or exceed those between the northwestern form of *taylori* and *T. crenularis* from off California, Oregon, and Washington.

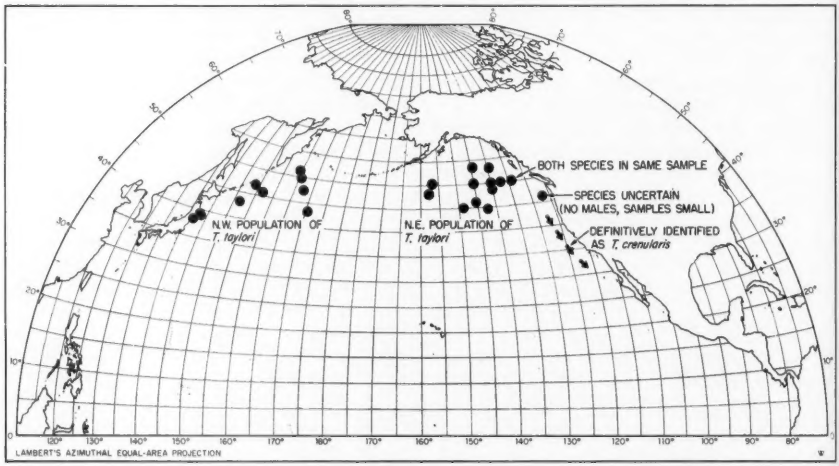

Fig. 1. Location of samples of *Tarletonbeania taylori* and *T. crenularis* studied.

All of the apparent clines tend in the same direction; the higher mean values for the northwestern form of *T. taylori* grade rather smoothly through means for the northeastern form into the means for *T. crenularis*. The obvious differentiation of the two forms of *T. taylori* and the apparent clinal relationship to *T. crenularis* suggests the possibility of hybridization.

However, all specimens of *T. crenularis* used in this study, plus many more not included in the statistical analyses, were examined for the simultaneous occurrence of both supracaudal and infracaudal luminous glands. No such occurrence was noted. Furthermore, there is a difference between the two species in the shape of the supracaudal

gland. In no specimen of *T. crenularis* did the elongate, thin gland resemble the consistently much shorter and bulkier gland of *T. taylori*. A few males of *T. crenularis* bore a distinctive, pale, elongate area in the region normally occupied by the infracaudal gland of *T. taylori*, but this pale area on close inspection was seen to be caused merely by an absence, or a thinning, of melanophores. No trace of luminous tissue could be seen on gross examination.

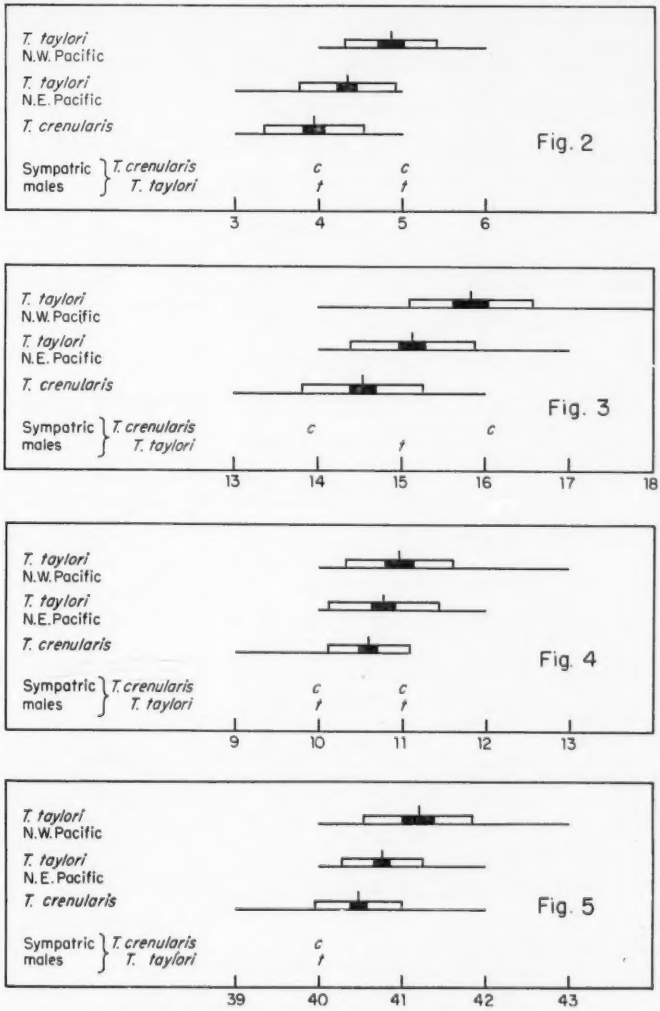

Fig. 2. Number of posterior anal organs (AOp).
Fig. 3. Number of total anal organs (AO).
Fig. 4. Number of anterior anal organs (AOa).
Fig. 5. Number of vertebral centra.

The consistent difference between the two species in the caudal glands does not in itself eliminate the possibility of hybridization. The presence or absence of the infracaudal gland, and the shape of the supra-

caudal gland, might be due to a single-factor Mendelian character. However, the distributional evidence indicates that *T. crenularis* does not commonly intermingle with *T. taylori*. The two were found together but once. Two males of each species were taken together at 50° 01′ N., Lat., 133° 58′ W. Long. lie at the extremes of the range of each species. But one character, total AO, may be said to approach the mid-point expected to result from hybridization (Fig. 3). This is also true for the total count of the two males of *T. taylori*. All other counts, except those for dorsal and pectoral rays, are identical

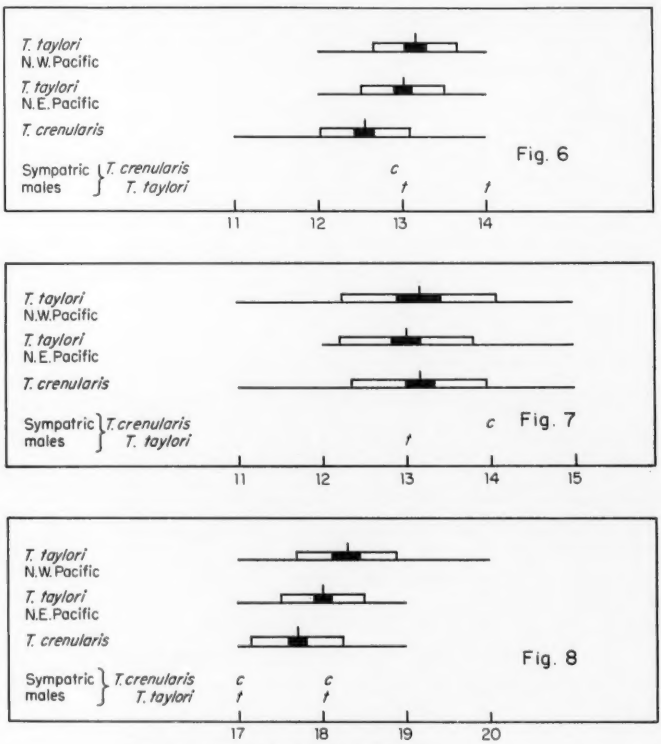

Fig. 6. Number of dorsal fin rays.
Fig. 7. Number of left pectoral fin rays.
Fig. 8. Number of anal fin rays.

(Fig. 1), along with ten females. In all meristic characters these females correspond with *T. taylori* rather than with *T. crenularis*. This may be an indication that *T. crenularis* seldom enters the area.

The counts of the two sympatric males of *T. crenularis* offer no conclusive evidence in regard to hybridization. As shown in Figures 2–8, one character may indicate a closer relationship to *T. crenularis* whereas another obviously favors *T. taylori*. Three characters show close relationship to *T. taylori* and three to *T. crenularis*. Two characters with those of the two males of *T. crenularis* (Figs. 2–8).

T. crenularis has been reported from the Gulf of Alaska, as follows: Bolin (1939) listed a specimen in the southern part of the Gulf, 49° N. Lat., 150° W. Long., but apparently the specimen was not examined by Bolin nor are any details given. Chapman (1940) listed a total of 18 specimens of *T. crenularis* ranging from near Kodiak Island, 57° 32′ N. Lat., 136° 25′ W. Long., across the Gulf to 55° 32′ N. Lat., 136° 25′ W. Long., and south to the Straits of Juan de Fuca. Almost all these

locations lie within the range of *T. taylori* and there is little to indicate that the specimens could not represent the species. Chapman stated that "no supra- or infra-caudal luminous scales or patches are present in the specimens . . .". Because of the lack of caudal luminous scales in the females and young of both species, and the considerable overlap in ranges of meristic characters, it is not possible to state with certainty that specimens without caudal luminous scales, represent *T. crenularis*.

If it is assumed that hybridization is not occurring and that *T. crenularis* may not be common in Gulf of Alaska waters, the immediate and obvious explanation of the pronounced differences between the northwestern and northeastern forms of *T. taylori* is that the two groups comprise distinct and self-sustaining populations. The very marked apparent clines that suggest intergradation with *T. crenularis* may be the fortuitous result of direct environmental influences or of convergent raciation.

In support of the idea of isolated, self-sustaining populations, as opposed to hybridization with *T. crenularis*, is the absence of any marked or consistent differences between the values of the standard deviations about the respective means (Table 1–3) such as would be expected if the northeastern stock of *T. taylori* has resulted from hybridization with *T. crenularis*. Only for the anal photophores do the values for the northeastern stock of *T. taylori* significantly exceed those for either

TABLE I

FREQUENCY DISTRIBUTION OF THE ANAL SERIES OF PHOTOPHORES OF *Tarletonbeania taylori* FROM THE NORTHWEST AND NORTHEAST PACIFIC OCEAN, AND OF *T. crenularis* FROM OFF THE COAST OF CALIFORNIA

AOa, Left

	9	10	11	12	13	N	Mean	$S(x-\bar{x})^2$	S.D.
T. taylori									
NW Pacific	. .	11	34	7	1	53	10.96	21.92	.6431
NE Pacific	. .	34	47	13	. .	94	10.78	42.31	.6709
T. crenularis	2	33	56	. .	. .	91	10.59	25.96	.5341

AOp, Left

	3	4	5	6	N	Mean	$S(x-\bar{x})^2$	S.D.
T. taylori								
NW Pacific	. .	11	38	4	53	4.87	14.08	.5508
NE Pacific	5	51	38	. .	94	4.35	31.41	.5780
T. crenularis	19	58	14	. .	91	3.95	32.73	.5997

Total AO, Left

	13	14	15	16	17	18	N	Mean	$S(x-\bar{x})^2$	S.D.
T. taylori										
NW Pacific	. .	2	13	31	6	1	53	15.83	29.47	.7457
NE Pacific	. .	18	49	24	3	. .	94	15.13	52.47	.7471
T. crenularis	6	37	41	7	. .	. .	91	14.54	48.62	.7310

TABLE II

FREQUENCY DISTRIBUTION OF NUMBERS OF VERTEBRAL CENTRA OF *Tarletonbeania taylori* FROM THE NORTHWEST AND NORTHEAST PACIFIC OCEAN AND OF *T. crenularis* FROM OFF THE COAST OF CALIFORNIA

The hypural element is included

Vertebral Centra	39	40	41	42	43	N	Mean	$S(x-\bar{x})^2$	S.D.
T. taylori									
NW Pacific	. .	5	26	12	1	44	41.20	19.16	.6599
NE Pacific	. .	29	70	4	. .	103	40.76	26.96	.4919
T. crenularis	1	60	56	1	. .	118	40.48	33.47	.5928

TABLE III

FREQUENCY DISTRIBUTION OF FIN RAYS OF *Tarletonbeania taylori* FROM THE NORTHWEST AND NORTHEAST PACIFIC OCEAN, AND OF *T. crenularis* FROM OFF THE COAST OF CALIFORNIA

Dorsal Rays

	11	12	13	14	N	Mean	$S(x-\bar{x})^2$	S.D.
T. taylori								
NW Pacific	. .	3	38	12	53	13.17	13.47	.5042
NE Pacific	. .	11	70	13	94	13.02	23.96	.5049
T. crenularis	1	38	49	1	89	12.56	25.91	.5395

Anal Rays

	17	18	19	20	N	Mean	$S(x-\bar{x})^2$	S.D.
T. taylori								
NW Pacific	2	35	14	2	53	18.30	19.17	.6014
NE Pacific	13	67	14	. .	94	18.01	26.99	.5052
T. crenularis	31	55	5	. .	91	17.71	28.57	.5604

Pectoral Rays

	11	12	13	14	15	N	Mean	$S(x-\bar{x})^2$	S.D.
T. taylori									
NW Pacific	1	13	19	16	4	53	13.17	47.47	.9464
NE Pacific	. .	25	41	20	3	89	13.01	56.99	.8002
T. crenularis	1	17	42	28	3	91	13.16	58.53	.8020

the northwestern form of *T. taylori* or *T. crenularis*.

The circumstances suggest that the northeastern stock of *Tarletonbeania taylori* is largely distinct and self-sustaining, but some recruitment from the northwestern stock is possible. In fact, it is conceivable that the northeastern population arises directly from the northwestern, by reasons of environmental modification, over two or three generations, of individuals being carried eastward along the Aleutian or Subarctic current. The current structure favors this possibility. The Aleutian, or Subarctic, current dominates the north Pacific above about 42° N. Lat. (Sverdrup, Johnson and Fleming, 1942, p. 722) and culminates in the Alaska and California currents. As this current moves eastward it becomes warmed to the degree that it may be characterized as a warm current despite the fact that it carries subarctic water. As all record stations of *T. taylori*, except the few reported by Mead, are in an area extending approximately from 42° to 52° N. Lat., and from 45° to 53° N. Lat., in the northwestern and northeastern Pacific, respectively, they all lie within the influence of this current. Available information indicates this to be a rather slow current, probably not exceeding an average of about six miles per day. Thus it may well be that one or more spawnings occur during any migration, along with possible phenotypic changes engendered by the somewhat different environment.

TABLE IV

FREQUENCY DISTRIBUTION OF NUMBERS OF GILL RAKERS OF *Tarletonbeania taylori* FROM THE NORTHWEST AND NORTHEAST PACIFIC OCEAN, AND OF *T. crenularis* FROM OFF THE COAST OF CALIFORNIA

The central raker is included in "Total Rakers"

Upper Rakers*

	4	5	6	N	Mean	$S(x - \bar{x})^2$
T. taylori						
NW Pacific	2	45	4	51	5.04	5.92
NE Pacific	2	80	1	83	4.99	2.99
T. crenularis	1	86	4	91	5.03	4.90

Lower Rakers*

	9	10	11	N	Mean	$S(x - \bar{x})^2$
T. taylori						
NW Pacific	4	43	4	51	10.00	8.00
NE Pacific	23	58	2	83	9.75	19.69
T. crenularis	18	69	4	91	9.85	19.85

Total Rakers

	14	15	16	17	18	N	Mean	$S(x - \bar{x})^2$
T. taylori								
NW Pacific	..	6	38	6	1	51	16.04	15.92
NE Pacific	1	23	57	1	1	83	15.73	26.17
T. crenularis	..	19	65	6	1	91	15.88	27.67

* The counts for the upper and lower rakers do not include the central raker.

However, all available temperature and salinity data for the respective areas occupied by *T. taylori* indicate rather moderate differences in environment. Schott (1935, pl. 27) shows summer surface salinities for the habitats of *T. taylori* to range from 34.0 to 32.5 parts per thousand between the northwestern and northeastern habitats respectively. Temperatures from the surface to 400 meters depth are essentially the same, ranging from 10 to 15 C° at 200 meters and from 2 to 5 C° at 400 meters. Apparently, however, all temperatures average a few degrees colder for the northwestern area north of the influence of the Kuroshio current extension (Schott, *op. cit.* pls. 31, 32) (Sverdrup, *et al*, *op. cit.*, chart III).

Whereas the surface salinities and temperatures may appear to differ significantly over the north Pacific, it must be remembered that the myctophid fishes make extensive vertical migrations, certainly to a depth of at least 200 meters. It is very probable that greater extremes of temperature and salinity are encountered in such migrations than are likely to occur in the surface waters within the respective habitats. Therefore, it can not be stated with confidence that the small differences between the two habitats of *T. taylori* can alone be responsible for the observed changes in meristic characters. In fact it is hardly plausible to assume that differentiation within *T. taylori* is directly induced by the environment.

A causal mechanism responsible for the isolation of the two populations of *T. taylori* may well be the eastward drift in the North Pacific and the divergence of the Aleutian current into the Alaska and California currents along the North American coast. The Alaska branch forms a gyral which dominates the Gulf region southward to about 50° N. Most of the specimens of the northeastern form of *T. taylori* were taken along this latitude. Assuming the species to

have originated in the northwestern Pacific, it is thus possible that the original migrants, upon reaching the Gulf of Alaska, remained under the influence of the gyral and did not return westward against the Aleutian current. The apparent failure to extend southward into United States waters, following the California current, may be due to a preference for the colder waters of the Gulf region, or possibly to inability to compete with the well-established *T. crenularis*.

It is concluded that the highly significant differences between the two segregated populations of *T. taylori* indicate that the northeastern form comprises an isolated population, chiefly confined to the Alaskan gyral, and largely uncontaminated by recruitment from the west or by hybridization with *T. crenularis* from the south.

Literature Cited

Bolin, Rolf L. 1939. A review of the myctophid fishes of the Pacific coast of the United States and of Lower California. Stanford Ichthyological *Bulletin*, 1: 101–5.

Chapman, W. M. 1940. Oceanic fishes from the northeast Pacific ocean. *Occasional Papers of the British Columbia Provincial Museum*, (2): 14–16.

Hubbs, Carl L., and Hubbs, Clark 1953. An improved graphical analysis and comparison of samples. *Systematic Zoology*, 2(2): 49–57.

——— ——— and Lagler, Karl F. 1947. Fishes of the Great Lakes region. *Bulletin Cranbrook Institute of Science*, 18: 9–10.

Mayr, E., Linsley, E. G., Usinger, R. L. 1953. Methods and Principles of Systematic Zoology, *McGraw-Hill Co., New York*, 146–7, table 12.

Mead, Giles W. 1953. *Tarletonbeania taylori*, a new lanternfish from the western north Pacific. *Zoologica*, 38, part 2: 105–8.

Schott, G. 1935. Geographie des Indischen und Stillen Ozeans, Verlag Von *C. Boysen, Hamburg*, pls. 27, 31, 32.

Sverdrup, H., Johnson, M. W., Fleming, R. H. 1942. The Oceans. *Prentice-Hall, Inc., New York*, Chart III.

Scripps Institution of Oceanography, University of California, La Jolla, California.

Notropis uranoscopus, a New Cyprinid Fish from the Alabama River System

Royal D. Suttkus

THE species here introduced, although common in the Cahaba River, apparently has not been taken in other parts of the Alabama River System. Numerous collections in neighboring drainages have not revealed this species. Counts and measurements were made following Hubbs and Lagler (1947: 8–15).

I am grateful to Henry Howell for gifts and loans of material from the University of Alabama (UA) and to Reeve M. Bailey for color notes and loan of material from the University of Michigan Museum of Zoology (UMMZ).

Notropis uranoscopus, *sp. nov.*
Skygazer Shiner

(Fig. 1)

Material.—Holotype, an adult male, Tulane University (TU) Catalog No. 15289, 44.7 mm. in standard length, from Cahaba River, 2.2 mi. N. Centerville, Bibb Co., Alabama; collected 17 March 1957 by Royal D. Suttkus, Rudolph J. Miller, John De Abate, and Helen V. Miller. Paratypes, all from Cahaba River, Bibb Co., Alabama: TU 18551 (18), 25 to 50 mm., taken with holotype; UMMZ 171747 (12), 31–42 mm., 23 May 1956, TU 18674 (8), 40–47 mm., 8 July 1958 and TU 19410 (21), 34–52 mm., 8 September 1958, 8.5 mi. N. Centerville at Hwy. 27 crossing; UMMZ 171147 (2), 31 and 34 mm., TU 18569 (2), 31 and 43 mm., TU 18570 (8), 30–46 mm., and UA (3), 30–31 mm., all collected 2 mi. S. Centerville on 5 July 1954; UA 408 (1), 41 mm., 6 mi. S. Centerville near Harrisburgh bridge, 15 July 1954.

Diagnosis.—A slim species of *Notropis* with a chevron-shaped spot at base of caudal, with 4—4 teeth, and 7 anal rays. It resembles *Notropis stramineus*[1] but differs in that the eyes are more superior and the snout is more acute.

Description.—The count of the holotype is given in bold face print. Pharyngeal tooth

[1] *Notropis stramineus* was formerly known as *Notropis deliciosus* (Suttkus, 1958: 317).

formula is 4–4 in 21 specimens examined, strongly hooked, grinding surfaces are moderately developed, inferior edge of grinding surface serrated and superior edge is entire. Anal ray count is 6 (in 1 specimen), **7** (53), and 8 (2). Pectoral ray count is 13 to 17, typically 14 to 16 (of 56 specimens one aberrant fin has 8 rays, one fin has 13 and one 17, **14** (10), 15 (71) and 16 (28). One of 56 specimens has 7 dorsal rays instead of the usual **8**; two specimens have 18 caudal rays instead of the usual **19** and two specimens have one pelvic fin with 7 rays instead of the usual **8**. The dorsal fin is somewhat less elevated in *N. uranoscopus* than in *N. stramineus* and the pelvic fins are decidedly shorter than in *N. stramineus*. The other fins are of about the same proportion in the two species. The dorsal fin is slightly pointed, the anterior rays usually are less than or subequal to posterior rays in the depressed fin. The dorsal fin is placed slightly posterior to the pelvic insertion, its origin is nearer the caudal base than the snout tip. The lateral-line is complete, nearly straight, and is slightly decurved anteriorly. The scales are of moderate size, 34 to **37** along lateral line (typically 35 or 36), 20 to 24 (typically 21 to 23), (**22**), around the body before the dorsal and pelvic fins, **12** (5–2–5) around the caudal peduncle, and there are 12 to 16 (usually 14), (**15**), in predorsal series. The predorsal scales are not crowded; in a few specimens some unusually large scales were found. These are two or even three times the size of adjacent scales and seem to be fused scales from two or more neighboring rows.

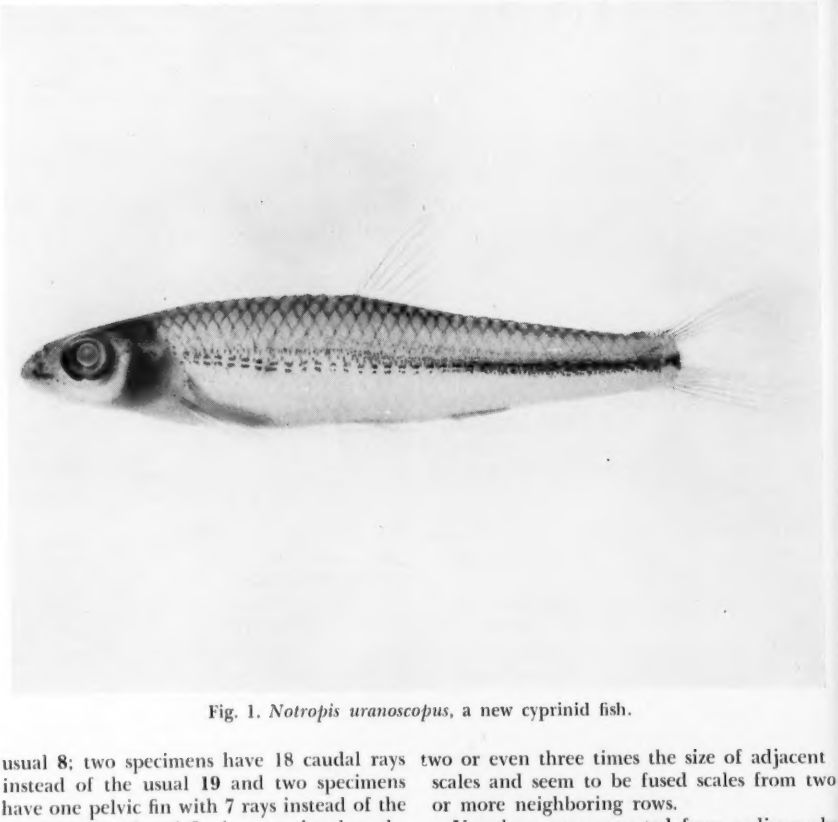

Fig. 1. *Notropis uranoscopus*, a new cyprinid fish.

Vertebrae were counted from radiographs of 47 specimens of *Notropis uranoscopus*. The elements of the Weberian complex are presumed to consist of 4 vertebrae and so the first vertebra to bear developed ribs is the fifth (Bailey and Suttkus, 1952: 7). The total vertebral count is 35 in 2 fish, 36 in 36, 37 in 8, and **38** in 1.

The body is subterete; the caudal peduncle slender; the head somewhat depressed; and the snout acute in lateral aspect. The cleft

of the inferior mouth is nearly horizontal; the mouth is moderate in size, and does not reach a vertical through the front margin of the eye. The eyes are placed high on the head and usually appear to be somewhat elongate. Measurements and selected meristic counts on the holotype and 20 paratypes are given in Table I.

Nuptial tubercles are well developed only in males. The dorsal and gular region of the head are densely covered with small tubercles, especially on the interorbital and supratemporal areas. The side of the head and snout are less so. The pectoral-fin tubercles are confined to the upper surface on the first to the seventh or eighth ray. The anterior pectoral ray sometimes lacks tubercles, but when present they are in a single row on the posterior margin of the ray. The second to the seventh rays have three or four rows of tubercles proximally and these rows extend distally onto the branches. However, the rows of tubercles are usually reduced to two distally so that there is only a single row on each branch. The posterior rays have a reduced number of rows and tubercles in each row. In the middle of the fin the nuptial organs are small, sharp, and close-set. The presence of tuberculated males in March, May, and July collections suggests a rather long spawning period.

Coloration.—*Notropis uranoscopus* is light, straw-colored species in life as well as in preservative. The dominant features of the preserved specimens are the small, dark, chevron-shaped, basicaudal spot and the paired, dark spots at each lateral-line pore. The posterior paired spots are obliterated in some specimens by the dark lateral pigmentation. The lateral band consists of a rather narrow band of fine punctulations anteriorly and is largely above the lateral-line pores from the cleithrum to above the origin of the anal fin. Posteriorly the melanophores are more numerous and the band incorporates the lateral-line pigmentation. Most of the ventral surface is devoid of pigment. A few scattered melanophores lie below the lateral-line anteriorly, especially between the insertion of the pectoral fin and the lateral-line. The widely-spaced melanophores on the lower sides of the caudal peduncle are oriented along the margins of the scale pockets; this arrangement is present anteriorly, as well, in some specimens. Most specimens have a few melanophores between the bases of the pelvic fins and some pigment immediately posterior to the anus. The latter pigmentation is usually continuous with that on either side along the base of the anal fin. The post-anal median stripe is composed of two or three rows of melanophores. The middle row persists anteriorly but terminates about half way to the base of the procurrent caudal rays.

The dorsolateral scales are each margined by a band composed of multiple rows of melanophores. Many scales have a double margin, the outer usually consisting of a single row of melanophores and this thin edging is separated by a non-pigmented area from the inner, marginal band. Two or three predorsal scales immediately in front of the origin of the dorsal and the post-dorsal median scales have their basal portions pigmented as well as their margins, however the pigmentation is of different density and arrangement so the marginal edging remains distinct.

TABLE I

PROPORTIONAL MEASUREMENTS AND COUNTS OF ADULTS OF *Notropis uranoscopus*

All proportions are expressed in thousandths of the standard length

Measurement or Count	Holotype TU 15289	20 Paratypes: TU 18551 (9); TU 18569; (1) TU 18570 (5); UMMZ 171147 (1); UMMZ 171747 (3); UA 408 (1)	
		Range	Average[1]
Standard length, mm.	44.7	32.0–50.5	40.2
Dorsal origin to snout	528	503–546	531
Dorsal origin to caudal base	497	487–516	498
Dorsal origin to occiput	318	297–329	310
Pelvic insertion to snout	492	483–513	494
Anal origin to caudal base	340	322–356	339
Body, greatest depth	197	172–228	195
Body, greatest width	139	113–164	139
Dorsal origin to lateral line	118	98–129	117
Pelvic insertion to lateral line	80	67–103	80
Caudal peduncle, length	248	226–249	240
Caudal peduncle, least depth	87	82–98	90
Head, length	259	247–278	265
Head, depth	148	141–163	151
Head, width	134	126–148	136
Interorbital, least fleshy	74	67–82	76
Snout, length	78	65–89	76
Eye, length	80	77–91	85
Upper jaw, length	71	69–85	76
Suborbital, least width	33	24–36	30
Dorsal fin, depressed length	201	192–224	204
Anal fin, depressed length	170	162–182	173
Caudal fin, base to tip	233	241–286	258
Pectoral fin, length	186	172–198	183
Pelvic fin, length	139	123–145	135

[1] Holotype not included.

The lateral band extends anteriorly on the upper part of the opercle and on the sides of the snout. There are two dark crescents in the internarial region, similar to those in *Notropis photogenis*. A heart-shaped dark patch of melanophores overlies the posterior part of the brain and an "H"-shaped patch overlies the anterior part. These two patches and the narial crescents are the outstanding features on the dorsal aspect of the head. The end of the snout is evenly pigmented as well as the upper lip; the lower lip has only a few melanophores on its mid-region.

The median fins have their rays margined with melanophores; the dorsal and caudal more so than the anal. Some specimens have only a few scattered melanophores along the anal rays. The posterior margins of the anterior pectoral fin rays are heavily pigmented. The pigmentation is progressively less toward the posterior part of the fin and several of the posterior pectoral rays lack melanophores. Many specimens exhibit a peculiar uniform spacing of the melanophores along the central rays of the pectoral fins. This unique pattern also exists in the pelvic of some specimens. Frequently the pelvic fins are devoid of pigment.

TABLE II

COMPARISON OF *Notropis uranoscopus* WITH *Notropis stramineus*

Proportions expressed in thousandths of the standard length

Measurement	*N. uranoscopus*[1]		*N. stramineus*[2]	
	Range	Average	Range	Average
Body, greatest depth	172–228	195	218–258	236
Dorsal origin to l.l.	98–129	117	131–141	137
Pelvic insertion to l.l.	67–103	80	94–123	107
Caudal peduncle, least depth	82–98	90	98–108	103
Head, depth	141–163	151	159–177	168
Interorbital, least fleshy	67–82	76	80–91	85

[1] Same data as tabulated under paratypes in Table I.
[2] Ten specimens from Texas: TU 10367 (6), TU 1486 (4).

Notropis uranoscopus is not a brightly colored species even during the breeding season. Color notes obtained on July 8, 1958 agree almost precisely with those generously loaned by Bailey for specimens collected on the 23 May 1956. The upper half of the body is straw-colored, the lower side silvery and the ventral surface white. The dark lateral band is hidden by silvery iridescence unless the fish is viewed from a certain angle. There is a golden stripe above the lateral band and another along the midline of the back. The entire inner rim of the iris is a rich, golden color and the outer upper surface of the eye has amber interspersed between the numerous melanophores. Silvery-blue flecks are present among the melanophores forming the two patches over the brain. The fins are clear and colorless.

Relationships.—*Notropis uranoscopus*, as mentioned above has certain characters in common with *Notropis stramineus* and apparently is closely related to it. *Notropis uranoscopus* is a more slender species (Table II), the inferior mouth terminates a little higher than in *N. stramineus*. In addition, the head of *N. uranoscopus* is more acute in lateral aspect and is markedly depressed. *Notropis uranoscopus* is remarkably close to *N. stramineus* in many body proportions. The exceptions are given in Table II and five of the six pertain to depth. Ventral pigmentation is more developed in *N. uranoscopus, i.e.* along anal fin base, lower part of side, and immediately posterior to anus and posterior to anal fin.

Habitat and Habits.—The holotype and 18 paratypes collected on March 17, 1957, were obtained from marginal currents in the Cahaba River. Those specimens that were seined in short hauls were taken from water of moderate current, of one to three feet in depth and from over gravel bottom. Seine hauls from quiet water over mud bottom and from torrential water in mid-stream failed to yield *Notropis uranoscopus*. Specimens collected on July 8, 1958, were seined at the beginning of a three-day rain. After about two hours of seining a single specimen of *N. uranoscopus* was obtained from the margin of the upstream end of a riffle. The water was approximately six inches deep and the bottom mostly gravel with some rubble. The larger rocks were removed by hand and several more hauls produced three more specimens from the same area. Several additional specimens were obtained from along the shallow side of another riffle. Repeated attempts in deeper water, faster current, slower current and from over sand, mud, and weedy areas did not catch any *Notropis uranoscopus*.

Nomenclature.—The name *uranoscopus* is derived from *uranus*, the sky, and *scopus*, a watcher, in reference to appearance of the fish looking skyward because of the supralateral position of the eyes.

LITERATURE CITED

BAILEY, REEVE M., AND ROYAL D. SUTTKUS. 1952. *Notropis signipinnis*, a new cyprinid fish from southeastern United States. *Occ. Pap. Mus. Zool. Univ. Mich., No. 542: 1–15, 2 pls., 1 map.*

HUBBS, CARL L., AND KARL F. LAGLER. 1947. (and 2nd printing, 1949). Fishes of the Great Lakes Region. *Bull. Cranbrook Inst. Sci., 26: i–xi, 1–186, many figs.*

SUTTKUS, ROYAL, D. 1958. The status of the nominal cyprinid species *Moniana deliciosa* Girard and *Cyprinella texana* Girard. *Copeia*, 1958 (4): *307–18, 8 figs.*

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Movements of Some Displaced Centrarchids[1]

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CERTAIN fishes of the family Centrarchidae are known to return to the site of capture after displacement within a lake (Cooper 1953, Hasler and Wisby 1958; see the recent review of Gerking (1959) for more examples of homing in freshwater fishes). Further studies of this nature were deemed necessary to ascertain and evaluate more fully the factors that influence the rate of return, the mechanisms involved, and the effect of nonrandom movement on Petersen-type population estimates. To reach these objectives, data on the summer distribution of marked and displaced largemouth bass *Micropterus salmoides* (Lacépède), bluegill *Lepomis macrochirus* Rafinesque, and pumpkinseed *L. gibbosus* (Linnaeus) were analyzed.

PROCEDURE

Three brown-water lakes in northern Wisconsin, Flora (102 acres), Dadek (24 acres), and Corrine (36 acres), were chosen for this project. The lakes lie in kettles of the pitted glacial outwash of Vilas County (Thwaites 1929), and have maximum depths of 20–30 feet. Fyke nets were employed exclusively to obtain specimens which were marked, moved by boat in open tubs to a central point, and released.

In 1955, eight shore areas of Flora Lake were established as capture sites, and combinations of two fin clips were utilized to recognize fish from each. The mid-points of these areas, together with the central location to which individuals were taken after capture, are shown in Figure 1. All marked largemouth bass (611), bluegills, pumpkinseeds, and hybrids of the latter two were adult fish, but fishes of different sex could not be separated readily. Since identification of some pumpkinseeds and hybrids proved uncertain in rapid handling, the 1,111 sunfishes other than bass were considered as a single group.

In Dadek Lake, eight permanent fyke-netting stations were designated during 1955 (1, . . . , 8) and again in 1956 (N, . . . , NW). Largemouth bass were tagged with Petersen tags (1,927 in 1955) or jaw tags (656 in 1956) and released at the same point (Figure 2).

Jaw-tagged bass (260) from Corrine Lake were treated similarly during 1956 (Figure 3).

RECAPTURES

Moderate variations occurred in the percentage of marked fish recaptured at the original capture site, and in every case the over-all distribution was decidedly nonrandom. The annual percentage of recaptures returning to the original site of capture ranged from 27.7 to 46.1, the remainder having been caught at one or more of the other seven stations.

Factors influencing observed movements.—Morphometric characteristics of the lakes, type of mark, and sex may account for some part of the differences observed; however, most of the emphasis will be concentrated elsewhere.

Season and year.—Largemouth bass finished spawning in these lakes by the third week of June. The other sunfishes in Flora Lake spawned throughout the entire summer, but more intensively during June. One might expect a greater motivation to return during these periods, but this was shown only by the bass in Flora and Dadek lakes where they

[1] Supported by grants from the Wisconsin Alumni Research Foundation, Wisconsin Conservation Department, Dairymen's Country Club, and Rainbo Lodge.

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returned more consistently in June 1955 (Table 1).

There is suggestive evidence from Corrine Lake that largemouth bass occupy the same territory in successive years. When the number of returns of bass marked in 1956 to the N, E, S, and W stations combined was compared for 1956 and 1957 (only four stations used in 1957), it was found that 121 out of 201 (121/201) and 47 out of 81 (47/81) had

Fig. 1. Mid-points of capture areas and central release point (+) for Flora Lake.

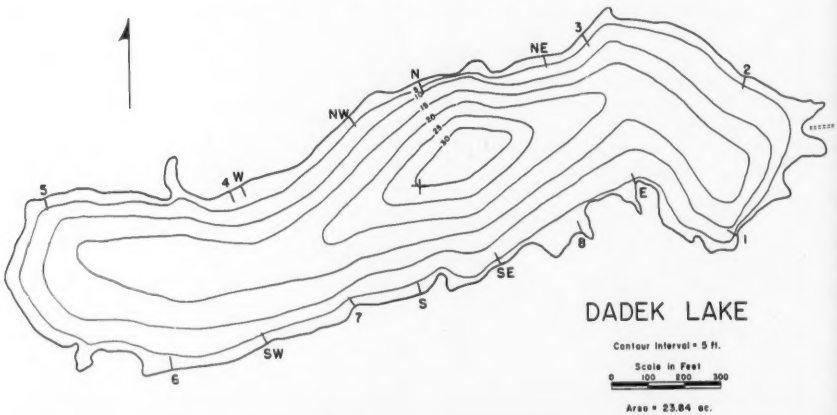

FIG. 2. Capture sites and central release point (+) for Dadek Lake.

returned to the original capture site, respectively. A like comparison from Dadek Lake showed an apparent decrease between years, 77/118 and 6/17.

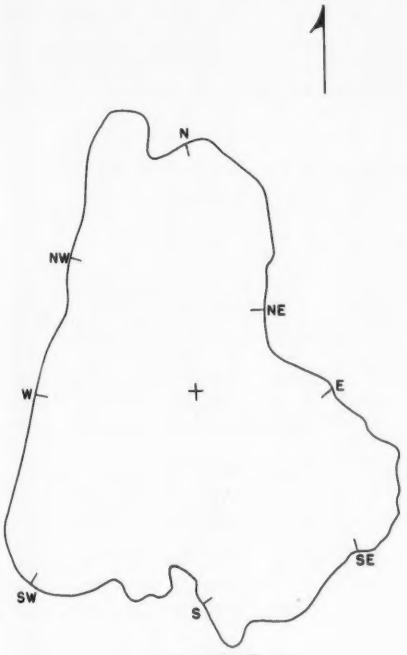

Fig. 3. Capture sites and central release point (+) for Corrine Lake.

Size and age of individuals.—It is commonly held that larger and older fish will return to the same territory more often than smaller and younger fish. Of the size-distribution-data available for initially recaptured bass from Dadek and Corrine lakes, only those from Dadek Lake during 1956 show some indication of this (Table 2).

All of the bass from the three lakes were at least two years of age, but the growth rate of Dadek Lake bass was much slower than the other two, presumably due to crowding. In Dadek Lake it required eight years for the bass to reach 10 inches (total length), twice as long as in Flora and Corrine lakes.

Time between marking and recapture.—Possibly, there would be a difference in the ability of individuals to return to the site of capture after being at large for varying periods between marking and initial recapture. This was apparently true during 1956 in both Dadek and Corrine lakes when bass which had been at large over 14 days were more

TABLE 1

INITIAL RETURNS TO THE ORIGINAL SITE OF CAPTURE BY DISPLACED FISHES OF FLORA, DADEK, AND CORRINE LAKES DURING 1955 AND 1956

	June		July		August	
	Number recaptured	Percentage return	Number recaptured	Percentage return	Number recaptured	Percentage return
Flora						
Sunfishes*						
1955	297	30.6	553	39.8	128	53.9
Largemouth bass*						
1955	91	42.9	446	28.5	630	33.0
Dadek						
Largemouth bass						
1955	45	46.7	75	37.3	32	31.2
1956	21	42.9	35	48.6	89	50.6
Corrine						
Largemouth bass						
1956	36	25.0	135	25.9	40	32.5

*Multiple recaptures included.

TABLE 2

INITIAL RETURNS TO THE ORIGINAL SITE OF CAPTURE BY DISPLACED LARGEMOUTH BASS ACCORDING TO SIZE

Total length (inches)	Dadek 1955		Dadek 1956		Corrine 1956	
	Number recaptured	Percentage return	Number recaptured	Percentage return	Number recaptured	Percentage return
3.9–5.0	6	33.3	6	16.7	0	
5.1–6.2	28	42.9	85	45.9	3	33.3
6.3–7.4	69	34.8	25	56.0	62	21.0
7.5–8.6	33	45.5	19	52.6	81	30.9
8.7–9.8	11	36.4	7	57.1	34	32.4
9.9–11.0	5	40.0	3	100.0	22	31.8
11.1–15.7	0		0		9	0.0

successful than those recaptured sooner (Table 3). It should be kept in mind, however, that the fish might have returned earlier but had not entered the net. On the other hand, they might have been better able to avoid the nets and come back to their original territories after prolonged movement.

Multiple recapture.—It has been suggested that experience in repeated recaptures could alter the percentage of returns. When the data are examined in this light, considerable variability is observed; however, there is no significant trend (Table 4). This result has been interpreted to mean that repeated experiences do not change the behavioral patterns operating here.

TABLE 3

INITIAL RETURNS TO THE ORIGINAL SITE OF CAPTURE BY DISPLACED LARGEMOUTH BASS AFTER BEING AT LARGE FOR SPECIFIED PERIODS SUBSEQUENT TO TAGGING

No. of days between tagging and first recapture	Lake	Year	Number recaptured	Percentage return
0–7	Dadek	1955	42	38.1
		1956	41	29.3
	Corrine	1956	68	22.1
8–14	Dadek	1955	35	40.0
		1956	24	41.7
	Corrine	1956	61	19.7
15 or more	Dadek	1955	75	38.7
		1956	80	61.2
	Corrine	1956	82	36.6
Total	Dadek	1955	152	38.8
		1956	145	49.0
	Corrine	1956	211	27.0

DISCUSSION

Distribution curves.—A simple mathematical expression was desired for the distribution of marked fish after displacement. To found this expression, the shortest water distance between stations was measured in 10-foot units and the recaptures were recorded as to station of marking and station of recapture. These data for Flora Lake are listed in Table 5. When the natural logarithm of one minus the proportion P, obtained by dividing the number of fish marked at station k and recaptured at a given station by the total number of recaptures marked at station k, is plotted against the natural logarithm of the distance D plus one, there is a nearly linear relationship. Regression analyses give equations for these lines and show correlations greater than 0.67 (Table 6). If these equations are solved for different values of P and D, the appropriate distribution curves are obtained, as illustrated in Figure 4. Upon scrutiny of these curves, it becomes apparent that most of the curvilinearity is caused by the eight percentages (not shown) of return to the original sites of capture. This led to comparing the regression equations derived after deleting these percentages with the corresponding means. The resulting errors of estimate are given in Table 7, and a minimum of calculation will show that all of the reductions due to regression are non-significant; that is, the proportion remains approximately constant with respect to the distance

TABLE 4

NUMBERS OF LARGEMOUTH BASS RECAPTURED n TIMES, WITH PERCENTAGE RETURN TO THE SITE OF ORIGINAL CAPTURE INDICATED FOR EACH GROUP

No. of times recaptured	Lake	Year	No. of fish	No. returning	No. captured elsewhere	Percentage return
1	Dadek	1955	112	44	68	39.3
		1956	107	53	54	49.5
	Corrine	1956	70	20	50	28.6
2	Dadek	1955	24	13	35	27.1
		1956	23	18	28	39.1
	Corrine	1956	66	39	93	29.5
3	Dadek	1955	10	15	15	50.0
		1956	9	16	11	59.3
	Corrine	1956	41	39	84	31.7
4	Dadek	1955	5	8	12	40.0
		1956	4	5	11	31.2
	Corrine	1956	16	9	55	14.1
5	Dadek	1955	1	4	1	80.0
		1956	2	3	7	30.0
	Corrine	1956	12	16	44	26.7
6	Corrine	1956	4	9	15	37.5
7	Corrine	1956	2	3	11	21.4

from the original site of capture. The same conclusion was reached when the 1957 data from Dadek Lake (four stations) were analyzed. These results suggest that part of the population returns to the capture site, but that the remaining fish wander about randomly. An estimate of the nonrandom portion is easily made by subtracting the fraction that would be expected to return by chance from the total proportion reaching the site of original capture (Table 8). Of course, some of the fish which have a preferred area would be intercepted by other nets as they moved along the shore, thereby reducing the estimated size of this group.

The nonrandom segment from Corrine Lake is of particular interest because bass from Dadek Lake were marked and introduced there in 1954. In contrast with the high percentage (49.0) of return of initial recaptures in Dadek Lake during 1956, only 32/127 or 25.2 percent of the initially recaptured, transferred fish were captured at the original site; native bass 25/84 or 29.8 percent. Apparently, the transferred individuals did not establish a large number of territories during the two years subsequent to stocking.

Mechanism of Homing.—The various modes of homing orientation have been conveniently classified by Griffin (1952). They are modified here as follows:

Type I: The ability of an animal to find home by relying on local landmarks within familiar territory and the use of exploration in unfamiliar areas.

Type II: The ability to maintain a constant compass direction in unfamiliar territory. This type is called *Richtungsfinden* (-fliegen) by Kramer (1953).

Type III: The ability to head for home from unknown territory by true navigation. Designated by Kramer (1953) as *Zielfinden*. This involves a "sextant" type of mechanism but as yet no observations have been made to describe its existence in fishes, although the birds appear to have one (Kramer 1952, and Sauer 1957).

It is extremely difficult to determine what mechanism or mechanisms are used by those fish returning to the site of original capture. Since the waters of the three lakes are deeply stained, light penetration is reduced greatly. This fact, together with the greater water

TABLE 5

SUMMARY OF THE NUMBERS OF RECAPTURED SUNFISHES* AND LARGEMOUTH BASS† TAKEN IN FLORA LAKE DURING 1955 AND THE SHORTEST WATER DISTANCES BETWEEN STATIONS IN 10-FOOT UNITS‡

Marking station	Station of recapture								
	1	2	3	4	5	6	7	8	Total
1	4*	1	2	2	0	2	0	0	11
	11†	5	4	12	3	6	3	1	45
	0‡	201	284	325	298	176	456	361	
2	13	70	37	13	10	35	15	24	217
	7	21	35	22	7	9	8	4	113
	201	0	189	258	235	131	366	270	
3	3	26	90	18	20	21	30	44	252
	11	27	113	60	25	33	22	23	314
	284	189	0	120	152	141	194	98	
4	1	6	2	18	2	2	5	3	39
	14	8	38	111	25	16	17	39	268
	325	258	120	0	80	160	217	104	
5	0	3	5	7	14	5	3	5	42
	3	7	9	16	20	12	4	7	78
	298	235	152	80	0	134	282	172	
6	14	42	37	17	11	115	14	26	276
	4	5	10	9	5	15	1	3	52
	176	131	141	160	134	0	302	205	
7	7	0	0	1	0	0	6	0	14
	8	5	32	33	6	20	64	32	200
	456	366	194	217	282	302	0	119	
8	0	7	8	6	5	5	33	63	127
	2	8	10	24	4	5	25	19	97
	361	270	98	104	172	205	119	0	

TABLE 6

LINEAR REGRESSIONS OF $\log_e (1 - P)$ ON $\log_e (D + 1)$ BASED ON RECAPTURE—DATA FROM FLORA, DADEK, AND CORRINE LAKES

Lake and species	Year	Intercept	Slope	r	Errors of estimate Sum of squares
Flora					
Sunfishes	1955	−0.49453	0.075142	0.780	0.75021
Largemouth bass	1955	−0.34729	0.044938	0.721	0.38526
Dadek					
Largemouth bass	1955	−0.45204	0.076827	0.679	1.08462
	1956	−0.65109	0.139571	0.811	1.29917
Corrine					
Largemouth bass	1956	−0.38173	0.060177	0.711	0.54389

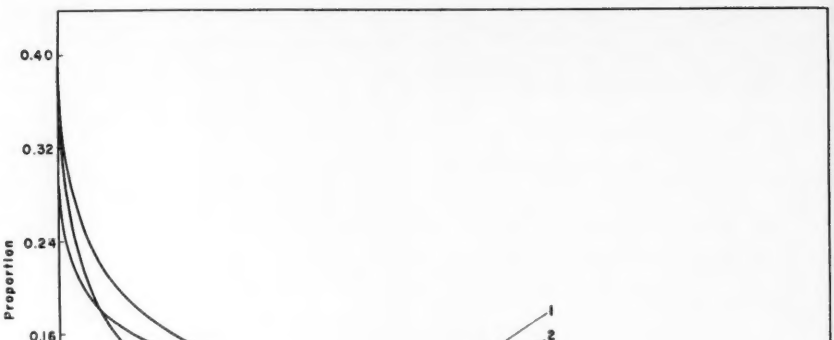

Fig. 4. Theoretical relative distributions during 1955 of some marked (1) largemouth bass in Dadek Lake, (2) bluegills, pumpkinseeds, and hybrids in Flora Lake, and (3) largemouth bass in Flora Lake.

TABLE 7

ANALYSIS OF THE ERRORS OF ESTIMATE WITH RETURNS TO THE SITE OF ORIGINAL CAPTURE OMITTED (NATURAL LOGARITHMS)

Lake, species, and year	Source of variation	d.f.	Sum of squares	Mean square
Flora				
Sunfishes (1955)	Dev. from mean	48	0.70062	
	Dev. from regr.	47	0.69894	0.01487
L. bass (1955)	Dev. from mean	48	0.35072	
	Dev. from regr.	47	0.34715	0.00739
Dadek				
L. bass (1955)	Dev. from mean	48	0.81054	
	Dev. from regr.	47	0.79927	0.01701
L. bass (1956)	Dev. from mean	48	0.80128	
	Dev. from regr.	47	0.77485	0.01649
L. bass (1957)	Dev. from mean	8	0.24880	
	Dev. from regr.	7	0.21781	0.03112
Corrine				
L. bass (1956)	Dev. from mean	48	0.37013	
	Dev. from regr.	47	0.36423	0.00775

depth at the release point, render unlikely the use of bottom contours as an immediate guide. Furthermore, the fish were too far from shore initially to utilize the treeline as a mark. Hasler *et al* (1958) have shown that white bass, *Roccus chrysops* Raf., when displaced in a lake, maintain a constant compass direction when the sun is shining but swim randomly when the sky is overcast. Training experiments showed further that this species and *Lepomis macrochirus* Raf., possess a sun-compass mechanism which is associated with an "internal clock". This type of sun orientation has been found in starlings by Kramer (1952) and can be classified as Type II orientation (Griffin, *loc. cit.*). If this behavior were true of these largemouth bass, the course that an individual takes after displacement

TABLE 8

ESTIMATES OF THE NONRANDOMLY MOVING SEGMENT OF THE MARKED FISHES IN FLORA, DADEK, AND CORRINE LAKES

Lake and species	Year	No. of recap.	Percentage		
			Returned to original site	Recaptured elsewhere (each of 7 sites)	Nonrandom segment
Flora					
Sunfishes	1955	978	38.9	8.7	30.2
Largemouth bass	1955	1167	32.0	9.7	22.3
Dadek					
Largemouth bass	1955	215	39.1	8.7	30.4
	1956	206	46.1	7.7	38.4
Corrine					
Largemouth bass	1956	487	27.7	10.3	17.4

should be in a constant compass direction. If they had Type III they would swim directly toward their home territory. This indicates the need for a method to determine the initial direction taken after displacement. Toward this end, the paths of some released bass in Dadek and Corrine Lakes were observed by direct tracing. As described by Hasler and Wisby (*op. cit.*), a small bobber was attached to a fine nylon line, 5–10 feet long, which in turn was tied to a hook forced into the flesh at the posterior end of the dorsal fin. One hundred and three (103) such bass were released individually at the central location, and the progress of each fish was charted with the aid of a rangefinder and a large compass until that individual reached shore (Table 9). The average speed ranged from 4.6 feet per minute in Dadek Lake during 1957 to 10.6 feet per minute in Corrine Lake during 1956. These values are minimal since the course of the fish was often an irregular one. Even at the lesser rate, a bass could, conceivably, reach the most distant part of the shore (1165 feet) in less than five hours. Furthermore, the average error in degrees from the "correct" direction ranged from 74.1 to 90.2, indicating nearly random movement from center to shore. These findings tend to support the hypothesis that bass returning to the original site of capture do so by searching along the edge of the lake (Type I homing orientation). One 11-inch fish in Corrine Lake was traced twice, and each time it made a center-to-shore error of 135 degrees, yet whenever recaptured (in all, 10 times), it was taken at its original station. These areas might be recognized by the acute olfactory sense present in certain fishes (Hasler and Wisby 1951), by seeing familiar landmarks on the shore or bottom, or by other mechanisms reviewed by Hasler (1956a, 1956b). However, the foregoing hypothesis might be modified if the extent to which an attached bobber influences behavior were known.

Further changes might be in order if territory-size could be established. During 1957, half of the fish caught at each net (N, E, S, or W) in Dadek Lake were tagged and released at the center, and the other half at the net. A breakdown of initial recapture data showed that of those displaced before release, 22/33 or 66.7 percent returned, but only 27/56 or 48.2 percent of the others were recaptured at the original site. This difference needs to be explained.

At this juncture it would appear that there are at least two types of homing orientation in fishes. Type I as illustrated by the green sunfish and largemouth bass and Type II by the white bass. Not only is more work needed to describe more fully these two types but an effort should be made to determine if the more elaborate ability as exemplified by Type III is used by fishes.

Effect on population estimate.—Inasmuch as population estimates are required for many studies of fishery biology, it is pertinent that the results reported here be related to this procedure. The non-random movement of displaced bass and the tendency of many individuals to remain in a limited territory during the summer months points up a source of error which will cause an

TABLE 9

MOVEMENTS OF LARGEMOUTH BASS (BOBBERS ATTACHED) REACHING SHORE WITHIN ONE HOUR AFTER RELEASE AT THE CENTER

	Year	Dadek Lake	Corrine Lake
No. of fish	1956	18	30
	1957	23	32
Mean time at large (min.)	1956	35.8	43.8
	1957	50.4	40.3
Mean speed (ft./min.)	1956	7.9	10.6
	1957	4.6	7.9
Mean error (degrees)	1956	88.9	79.9
	1957	74.1	90.2

underestimate if neglected. As a first approximation, consider a population which is sampled with net positions remaining fixed, and which does not have all of its marked members moving at random. A simple Petersen-type estimate of the total number N is given by Mn/m where M is the number marked and released, n is the total number taken in a subsequent sample, and m is the number of recaptures among n. If the nonrandom fraction a is eliminated, the result should be improved. Consider the following modification of the estimator:

$$N = \frac{M(n - am)}{m - am}$$

$$= \frac{Mn - Mam}{m(1 - a)}$$

$$= \frac{Mn}{mb} - \frac{Ma}{b}$$

where $b = l - a$. If $M = 1000$, $n = 1000$, $m = 100$, and $a = 0.3$, the unmodified estimate is 10,000, whereas the modified value is 13,857.

The above procedure for processing population data is one improvement that could be made in an estimation of numbers of bass in a lake during the summer. Obviously it would be preferable to make the population estimate at a time of year when the bass were moving more randomly. Needless to say, more thorough experimentation in the field with modified capture techniques and improvements in statistical methodology are desirable in order to improve the accuracy of estimating the size and change in a population of fishes. The non-randomness of movement is only one of the behavior characteristics of fish which alter their distribution and patterns of migration. Other factors may include the degree of crowding, as well as many sensory stimuli other than those involved in homing orientation.

Summary

1. During 1955–1957, largemouth bass and other sunfishes were fyke netted from three northern Wisconsin lakes, marked, displaced to a central point, and released.

2. The annual percentage of recaptures which returned to the eight sites of original capture combined ranged from 27.7 to 46.1.

3. The percentage of return to the original sites of capture was usually unaltered by season, size of individuals, and multiple recaptures. On the other hand, bass which were at large longer than 14 days before initial recapture ordinarily returned more successfully than those at large for shorter periods.

4. Curvilinear functions were used to summarize the distribution of marked individuals after displacement. It was shown that large parts (61.6–82.6 percent) of these populations were being recaptured in a nearly random manner.

5. Those fish which did return to the original site of capture apparently did so in an indirect way, *i.e.*, by searching for the area along the shore rather than going there directly from the center.

6. A modified Petersen-type population estimate is proposed for specified conditions of sampling and nonrandom movement of marked fish.

Literature Cited

Cooper, G. P. 1953. Population estimates of fish in Sugarloaf Lake, Washtenaw County, Michigan, and their exploitation by anglers. *Pap. Mich. Acad. Sci. 38: 163–86.*

Gerking, S. D. 1959. The restricted movement of fish populations. *Biol. Rev.* (in press)

Griffin, D. R. 1952. Bird navigation. *Biol. Rev. 27: 359–93.*

Hasler, A. D. 1956a. Influence of environment reference points on learned orientation in fish (*Phoxinus*). *Z. vergl. Physiol. 38: 303–10.*

—— 1956b. Perception of pathways by fishes in migration. *Quart Rev. Biol. 31(3): 200–09.*

——, and W. J. Wisby. 1951. Discrimination of stream odors by fishes and its relation to parent stream behavior. *Amer. Nat. 85: 223–38.*

——, and —— 1958. The return of displaced largemouth bass and green sunfish to a "home" area. *Ecology 39: 289–93.*

——, H. M. Horrall, W. J. Wisby, and W. Braemer. 1958. Sun-orientation and homing in fishes. *Limnol. Oceanogr. 3(4): 353–61.*

Kramer, G. 1952. Experiments on bird orientation. *Ibis 94: 265–85.*

—— 1953. Wird die Sonnenhöhe bei der Heimfindeorientierung verwertet? *J. Ornithol. 94: 265–85.*

Sauer, F. 1957. Sternenorientierung nächtlich ziehender Grassmücken (*Sylvia atricapilla, borin und curruca*). *Zeit. Tierpsychol. 14(1): 29–70.*

Thwaites, F. T. 1929. Glacial geology of part of Vilas County, Wisconsin. *Trans. Wis. Acad. Sci. 24: 109–25.*

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Ovary Weights of Darters: A Test of the Alleged Association of Parental Care with Reduced Fecundity in Fishes[1]

George C. Williams

Fishes that provide much care and protection for their eggs supposedly produce fewer eggs than those that provide little or no protection. This rule is stated in general zoological works (Allee, *et al.*, 1949: 685), in general works on fishes (Curtis, 1940: 180), and in papers on fish reproduction (Fahy, 1954). A functional basis for this relationship

[1] Contribution Number 108 from the Department of Natural Science, Michigan State University, East Lansing, Michigan.

is usually implied, as in Curtis' succinct explanation, "The more parental care, the fewer eggs are necessary." Efforts at explanation are premature, however, unless the phenomenon to be explained is well documented. Evidence presented in this paper indicates that the one in question is not.

The number of eggs laid by a fish is equal to the total mass of the eggs, a variable proportion of the fish that lays them, divided by the average mass of a single egg. So fecundity may be expressed by the equation

$$N = pF/m$$

where N is the number of eggs, p a proportionality coefficient, F the parental body mass, and m the mean mass of a single egg. The factor p would be a measure of physiological effort expended on fecundity. A fish that spawned a mass of eggs equal to a large proportion of body weight at frequent intervals in a long breeding season would have a high p-value. One that spawned a relatively small mass once a year would have a low p-value.

If the evolutionary development of parental care entails a reduction of fecundity, this reduction could result from lowering the value of p, lowering the value of F, or increasing the value of m. References to fecundity reductions associated with parental care have seldom been explicit as to which of these factors are involved. Breder (1935) produced evidence that the evolution of oral incubation from nesting behavior usually results in an increased egg size and proportionate reduction in fecundity. No one has claimed, however, that species that guard their eggs in nests lay larger eggs than those that leave them unattended, nor has anyone suggested that the evolutionary development of parental care brings about a reduced body size. There may well be some statistical correlations between parental care and egg size or body size. However, those who have proposed an inverse functional relationship between fecundity and parental care clearly imply that parental care must bring about a reduced physiological emphasis on fecundity. The effect of parental care should be in addition to those of obvious mechanical factors such as egg size or body size and should therefore be sought by comparing values of p for species that have parental care and those that do not.

Such a study has not been attempted. All the evidence offered on this problem has consisted of egg-count comparisons with no attempt to adjust for differences in body size or egg size. Hall[2], for instance, compared a number of species and found that, as a general rule, those that practice parental care produce fewer eggs than those that do not. It happened, however, that most of his examples of species with parental care were smaller than those with which they were compared. At least part of the fecundity variation must have been due to size variation. Fahy (1954) made a similar comparison between species of egg-tending darters, with maximum body masses of a few grams, and other percids, including such large species as the perch and the walleye, that do not tend their eggs. He found that the egg tenders had the lower average fecundity, but failed to adjust for differences in size. By a proper selection of examples one can easily "demonstrate" the opposite relationship, that parental care is associated with increased fecundity. The larger centrarchids have better developed parental care than the smaller ones (Breder, 1936), and, according to Carlander's (1953) tables and to general expectation, the larger species have the higher egg counts.

Parental care is known primarily among freshwater fishes, which are usually small in size. The largest fishes with parental care for which I have found fecundity records are the shovelhead catfish, *Pilodictis olivaris*, and the lingcod, *Ophiodon elongatus*. Breder (1935) reported an egg count of about 100,000 for a four-foot specimen of the catfish, and Clemens and Wilby (1946) reported a 46½-inch lingcod that contained 476,000 eggs. The higher value for the lingcod is attributable to its much smaller eggs. Many fishes that combine parental care and a small body size are very fecund on the basis of eggs per unit mass of parent. Raney and Lachner (1939) reported an egg count of 400 for a 50-mm. darter, *Etheostoma maculatum*, one of Fahy's (1954) examples of parental care and reduced fecundity. This corresponds to a count of 400,000 eggs of the same size in a 500-mm. fish. The crappie *Pomoxis nigromaculatus* guards its eggs in a nest, but Vessel and Eddy (1941) found an 8-oz. specimen with 98,000 eggs in its ovaries. These figures compare favorably with the fecundity of any American freshwater fish, on the basis of eggs per unit weight of parent (Carlander, 1953).

Statements on fecundity per unit weight of parent are meaningful only when eggs of constant size are involved. Actually fish eggs vary tremendously in size, and, as expected,

[2] Mark A. Hall's unpublished Master of Science Thesis, University of Rochester, 1935.

species with large eggs lay fewer than those that lay small eggs. There can be no doubt that an increase in egg size, due to provisioning with greater yolk reserves, necessitates a reduced fecundity. The evolutionary implications of this sacrifice of fecundity for increased egg nutrition have been ably discussed by Svärdson (1949), and by Hubbs (1958).

Interspecific comparisons of ovary weight per unit body weight, although only a part of the factor p in the fecundity equation, are at least free of the direct influence of egg size and body size. Unfortunately there are but few records of mature ovary weights. Among species that do not guard their eggs the greatest recorded relative ovary weight is that of a lake lamprey (landlocked *Petromyzon marinus*). Gage (1928) found a specimen in which the ovaries comprised 36% of the total. If this is a usual figure for this species, its high value may be due to the atrophy of the digestive organs prior to the single spawning. This removal of digestive organs would allow much additional material and space for gonad development. The figure may be exceptional, however. Gage's figures for a sea lamprey (*P. marinus*) on its spawning migration indicate a relative ovary weight of only 19 percent. Eschmeyer (1950) recorded an average relative ovary weight of 27 percent and an extreme of 31 percent for a series of walleyes, *Stizostedion vitreum*. These are the highest figures I have found for the mature ovary weights of species that spawn more than once and do not guard their eggs. Other series of this species studied by Eschmeyer had relatively smaller ovaries. Bagenal (1957) stated an average relative ovary weight, at maximum development, of about 18 percent for a flatfish, *Hippoglossoides platessoides*. Eschmeyer and Bailey (1954) found an average relative ovary weight of 15 percent in a series of whitefish, *Coregonus coulteri*, and Eschmeyer (1955) found maximum ovary development to be 12 percent of total weight in a population of lake trout, *Salvelinus namaycush*. The bigeye tuna, *Parathunnus sibi*, has surprisingly small ovaries. Among 1,240 examined by Yuen (1955), many of which had mature eggs, the greatest relative ovary weight was about 5 percent.

Among species that guard their eggs there are records for a sculpin, a pout, and various centrarchids. The greatest relative ovary weight, 33 percent, was recorded by Hann (1927) for the mottled sculpin, *Cottus bairdi*, apparently as an average condition. This value is suspiciously high. Perhaps Hann meant 33 percent of the body weight exclusive of ovaries, or 25 percent of the total. Olsen and Merriman (1946) recorded an average relative ovary weight of 11 percent for the pout, *Macrozoarces americanus*. Ovaries of centrarchids weighed by Morgan (1951) were quite variable. The maximum relative weight was 20 percent, and the average much less, perhaps 10 percent in the peak of the spawning season. The centrarchids studied sometimes have larger numbers of eggs in their ovaries than Morgan recorded, however (Carlander, 1953). So at times they must have either greater relative ovary weights or smaller eggs than Morgan encountered.

These records of relative ovary weights hardly indicate any very striking dependence on breeding habits. The information is scanty, however, and does not rule out the possibility of a slight statistical correlation between relative ovary weight and the amount of care the eggs receive. To investigate this possibility I undertook a study of relative ovary weights of darters. These fishes are well suited to such a study. The breeding habits of a number of species have been described in detail. We know that the males of some forms care for their eggs in various ways until they hatch, while in other species the eggs are deserted after fertilization. Within the large genus *Etheostoma* both conditions occur. It is possible to compare species that are closely related, and very similar in most respects, but which differ markedly in the amount of care and protection received by the eggs.

Materials and Methods

Winn (1958A, 1958B) has summarized the available information on the breeding habits of a number of darters. Three species of *Etheostoma*, *E. nigrum*, *E. flabellare*, and *E. maculatum*, are known to guard their eggs and to tend them in various other ways. Because collections of the first two were readily available, they were chosen to represent the group. Several species are known to leave their eggs completely unattended. Some of these give indirect protection against predators of their own species, which may be abundant on the breeding grounds, by maintaining permanent territories in which the eggs are laid. *E. caeruleum* and *E. spectabile*, however, do not maintain permanent territories, and even indirect protection does not occur. The eggs are buried a few millimeters deep and then deserted. Since large collections of

these two species were available they were chosen to represent the group in which parental care is absent.

Most of the pertinent collections kept at the University of Michigan Museum of Zoology and at the Chicago Natural History Museum were examined. Any collection of adult females caught in April or May in the Great Lakes region, or in March farther south, was considered pertinent, since this period would include nearly all of the breeding season for each of the four species. Such collections usually contain females with ovaries that have not quite reached full development or females that have already spawned some of their eggs, or both. These variables greatly influence mean ovary development, but not the maxima. It was my primary intent, therefore, to obtain estimates of maximum, rather than mean, ovary development. So I did not weigh the ovaries of all the females in a collection, but only those that seemed, from the amount of abdominal distention, to be well above the species average in relative ovary weight. Such fish constituted from 0 to 100 percent of the females in a collection. I tried to weigh about the same proportion for each species, so as to minimize any bias resulting from this subjective selection of specimens.

The fish were first removed from ethyl alcohol and soaked in water while they were sorted to sex and maturity. Specimens to be weighed were shaken to remove water from the mouth and pharynx and were dried on a paper towel. They were weighed and then opened and the ovaries removed and weighed as rapidly as possible to minimize evaporation. Weights were recorded to the nearest milligram.

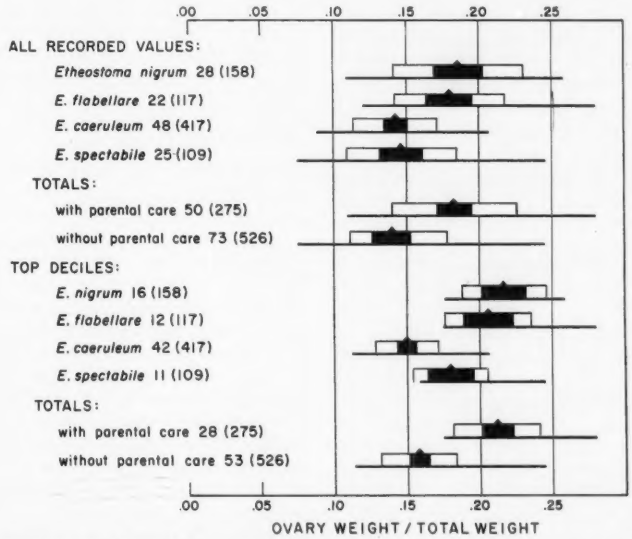

Fig. 1. Relative ovary weights of darters with and without parental care. The graphic form is that of Hubbs and Hubbs (1953). Observed range of variation (horizontal lines), mean (central peak), and intervals of two standard errors (black rectangles) and one standard deviation (open rectangles) on either side of the mean are shown for the four species and for combined data of species with and without parental care. Lack of overlap of the double standard-error intervals indicates a high degree of statistical significance. Numbers following species names are numbers of fish weighed and (in parentheses) total number from which they were selected.

Observations

The theory being tested is that parental care is associated with reduced fecundity (egg number), and that this reduction would be indicated by a lesser relative ovary weight in darters that practice parental care than in those that do not. My observations (Fig. 1) indicate that the opposite is true. The species with parental care have the greater ovary weights. This is true for the general means as well as the means of the top deciles, and,

as the figure indicates, the differences are of high statistical significance.

I am not able to offer any assured explanation for this surprising relationship between ovary size and parental care, although certain possibilities suggest themselves. Winn (1958B) found that the two species with parental care have shorter breeding seasons than the other two, although the breeding of *Etheostoma caeruleum*, and perhaps others, is dependent on certain weather conditions and is not continuous through the whole season. Perhaps the greater emphasis on ovary development is some sort of compensatory adjustment to the shorter breeding period. Or perhaps both the highly developed parental care and the greater ovary development reflect a greater general emphasis on reproductive functions in the species involved.

TABLE I

WEIGHT FREQUENCY DISTRIBUTIONS OF MATURE FEMALES OF THE FOUR SPECIES OF DARTERS

	Species	Weights in grams, ovaries included					
		0–0.5	0.5–1.0	1.0–1.5	1.5–2.0	2.0–2.5	>2.5
All recorded weights	*Etheostoma nigrum*	0	9	11	6	0	2
	E. flabellare	1	10	4	6	1	0
	E. caeruleum	0	4	22	13	6	3
	E. spectabile	0	10	5	6	3	1
Top deciles	*E. nigrum*	0	3	7	5	0	1
	E. flabellare	0	7	0	5	0	0
	E. caeruleum	0	4	18	13	5	2
	E. spectabile	0	4	2	3	2	0

I believe that sampling bias can be ruled out as a possible explanation. Collections of all four species came from diverse localities in the Great Lakes region and central states as far south as Kentucky. All four were represented primarily by fish caught in April, except for *Etheostoma flabellare*, for which May collections predominated. Two collections of *E. caeruleum* were taken in March from Kentucky. Nearly all of the collections examined contained females with mature eggs. About 20 percent of all specimens examined were weighed, except for *Etheostoma caeruleum*, of which only about 12 percent were weighed. So the weighed specimens of this species were more highly selected, but nevertheless, it had the lowest relative ovary weights. There could hardly be any bias associated with size or age differences in ovary development. All four species are of about the same size. Eddy and Surber (1947) state the maximum length of each to be 2-½ inches, except for *Etheostoma spectabile* which they did not consider. This species is very similar in size, as well as other external characters, to *Etheostoma caeruleum*. There is little interspecific variation in the absolute weights that I recorded, and no tendency towards size homogeneity of fish in the top decile of relative ovary weights (Table 1).

I omitted from the table and figure a record of a 43-mm. *Etheostoma nigrum* with a relative ovary weight of 41 percent. Since this value was more than 50 percent greater than the next highest recorded value for this species, I chose to regard it as an abnormality. The eggs, however, appeared to be perfectly normal. Abdominal distension in this specimen (UMMZ 118504) was so extreme as to give it a tadpole-like appearance.

DISCUSSION

Comparisons between species with respect to fecundity have usually been based on counts of mature eggs, or sometimes of all yolked eggs, in the ovaries of preserved specimens. For reasons already stated, I believe that comparisons of relative ovary weights are a more meaningful test of the influence of parental care on fecundity. Differences due to variations in egg size and body size are thereby eliminated. It is not fecundity as such that is of interest here, but the influence of parental care on fecundity.

Nevertheless, the method is still open to criticism. The ovary of a preserved specimen represents a standing crop of eggs at the time the fish was collected. The standing crop, as many ecologists have pointed out, may be unreliable as an index of productivity. Knowledge of the rate at which eggs are laid and replaced is essential to any attempt at estimating the total number of eggs, total mass of gametic material produced in a breeding season, or the crucial factor p in the fecundity equation. This information is lacking for darters. All darter life-history accounts indicate that females spawn repeatedly during the breeding season, but there is seldom any indication of what the total number of eggs produced might be. Counts of eggs deposited over a period of time in aquaria have been reported occasionally, but the durations of these egg laying periods are usually much less than the species breeding seasons in nature. High aquarium temperatures appear to curtail egg production. By keeping temperatures below a critical threshold Hubbs and Strawn (1957) were able to

keep females of *Etheostoma lepidum* in breeding condition for over eight months. During this period one fish laid nearly 10,000 eggs. Egg diameters were not stated, but even if the eggs were only a millimeter in diameter, smaller than the eggs of any of the four species considered in this report, the fish laid several times her own weight in eggs.

Even late in the breeding season the ovaries of the darters I examined contained an abundance of immature yolked eggs of various sizes, as well as mature eggs. Apparently these species, like *Etheostoma lepidum*, are capable of prolonged spawning activity, although in nature the immature eggs present late in the season are probably resorbed. MacGregor (1957) indicated that this may be the general rule for fishes that spawn several times in a breeding season.

Despite the lack of reliable estimates of the average rate of egg replacement in any species of darter, I believe that the information at hand is of some value. The rate of turnover of ovarian material is important to total egg production, but so is the mass of the ovary. If reduced fecundity is an evolutionary concomitant of the development of parental care, a decrease in the ovarian mass would seem to be an ecologically expedient way of achieving this reduction, at least in part. A fish with ovaries of 20 to 25 percent of total weight, apparently a common condition in some species of darters, bears a considerable mechanical burden. Besides the problem of an increased mass to be moved, in proportion to the machinery that moves it, the machinery itself must surely be hampered by the decreased flexibility of the trunk and the impairment of streamlining that accompany maximum ovary development. Full development can be achieved only at the cost of some mobility. A gene that would reduce these disadvantages should certainly be favorably selected were it not for the disadvantages of decreased numbers or sizes of eggs. So it is reasonable to suppose that an evolutionary trend towards reduced fecundity would manifest itself in reduced ovary size. It is quite unreasonable to suppose that it should be accompanied by increased ovary size. It is unlikely, therefore, that the evolutionary development of parental care in darters has brought about any reduction in fecundity.

There is no reason to believe that the darters considered in this study are unusual in this respect. A swollen abdomen, due to enlarged ovaries, is a general characteristic of female fishes before spawning, not merely of species that do not guard their eggs. Probably the most celebrated example of parental care in fishes is the threespine stickleback. Tinbergen (1953: 27–8) has shown that a distended abdomen in the female is necessary as a social releaser in courtship in this species. Tinbergen's illustrations of breeding females (pp. 10 and 27) probably represent extreme conditions. Apparently, however, fecundity is greatly emphasized in this species, despite the high development of parental care.

From a theoretical point of view these conclusions should occasion no surprise. Differential reproductive survival is the essence of natural selection. A reduction in fecundity, as such, can never be favorably selected, unless it is a necessary condition of some advantageous development, such as increased egg size or reduction of physiological stress on the parent. These considerations apply to all species, no matter how well the offspring are cared for by their parents. The result of this reproductive competition, as has often been observed, is that zygote production in most species is a wasteful process, far in excess of what is necessary to maintain adult population levels. In all probability the rate of survival to hatching is greater in darters that guard their eggs than in those that do not. In stable populations, however, this greater excess of young at the hatching stage must result in greater mortality rates after hatching. These arguments as applied to darters parallel those developed by Lack (1955) for animals in general.

Lack expressed the opinion that fecundity in fishes is limited mainly by the availability of food reserves that can be converted into eggs. Among the darters that I examined the individuals with greatest ovary development usually had considerable fat reserves in the intestinal region. Food may well be the limiting factor up to a certain point, but beyond that point the mechanical restrictions on the amount of space in the body cavity and the necessity of maintaining locomotor functions at a reasonable level of efficiency probably become the limiting factors.

Acknowledgments

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Hubbs of the University of Texas provided helpful advice in the preparation of the manuscript.

Summary

Large fish lay more eggs than small fish, and those that lay small eggs lay larger numbers than those that lay large eggs. It has also been claimed that species that display parental care lay fewer eggs than those that leave their eggs unattended. This decreased fecundity associated with parental care is presumably independent of the effects of egg size and maternal size. So the effect of parental care should be sought in some factor independent of egg size or absolute body size. The ratio of ovary weight to body weight is such a factor. The literature does not indicate any reduction of relative ovary weight in egg-guarding species, and my observations on four species of darters showed that the two egg-guarding species had greater relative ovary weights than the two that desert their eggs. I conclude that the evolutionary development of egg-guarding behavior does not entail a reduction in fecundity.

Literature Cited

Allee, W. C., Alfred, E. Emerson, Orlando Park, Thomas Park, and Karl P. Schmidt. 1949. Principles of animal ecology. *Saunders, Philadelphia.*

Bagenal, T. B. 1957. The breeding and fecundity of the long rough dab, *Hippoglossoides platessoides* (Fabr.), and the associated cycle in condition. *Jour. Mar. Biol. Assn., U. K., 36: 339–75.*

Breder, Charles M. 1935. The reproductive habits of the common catfish, *Ameiurus nebulosus* (LeSueur), with a discussion of their significance in ontogeny and phylogeny. *Zoologica, 19: 143–79.*

———. 1936. The reproductive habits of North American sunfishes (family Centrarchidae). *Zoologica, 21: 1–48, 7 pls.*

Carlander, Kenneth D. 1953. Handbook of freshwater fishery biology with the first supplement. *W. C. Brown, Dubuque, Ia.*

Clemens, W. A. and G. V. Wilby. 1946. Fishes of the Pacific coast of Canada. *Fish. Res. Bd. Can., Bull., 68: 1–368.*

Curtis, Brian. 1940. The life story of the fish. *D. Appleton-Century Co., New York.*

Eddy, Samuel and Thaddeus Surber. 1947 Northern fishes. *Univ. Minn. Press.*

Eschmeyer, Paul H. 1950. The life history of the walleye, *Stizostedion vitreum vitreum* (Mitchell), in Michigan. *Bull. Inst. Fish. Res., Mich. Dept. Conserv., 3: 1–99.*

———. 1955. The reproduction of lake trout in southern Lake Superior. *Trans. Amer. Fish. Soc., 84: 47–74.*

——— and Reeve M. Bailey. 1954. The pygmy whitefish, *Coregonus coulteri,* in Lake Superior. *Trans. Amer. Fish. Soc., 84: 161–99.*

Fahy, William E. 1954. The life history of the northern greenside darter, *Etheostoma blennioides blennioides* Rafinesque. *Jour. Elisha Mitchell Sci. Soc., 70: 139–205.*

Gage, Simon H. 1928. The lampreys of New York State, life history and economics. *N. Y. St. Conserv. Dept. Ann. Rept., 17 (suppl.), 158–91, 2 pls.*

Hann, Harry W. 1927. The history of the germ cells of *Cottus bairdi* Girard. *J. Morph. and Physiol., 43: 427–97.*

Hubbs, Carl L. and Clark Hubbs. 1953. An improved graphical analysis and comparison of series of samples. *Syst. Zool., 2: 49–56, 92.*

Hubbs, Clark. 1958. Geographic variations in egg complement of *Percina caprodes* and *Etheostoma spectabile. Copeia (2): 102–5.*

——— and Kirk Strawn. 1957. The effects of light and temperature on the fecundity of the greenthroat darter, *Etheostoma lepidum. Ecol., 38: 596–602.*

Lack, David. 1954. The evolution of reproductive rates. In *Evolution as a process* (Ed. J. Huxley, A. C. Hardy, E. B. Ford). *Allen and Unwin, Ltd., London, 1–376 (143–56).*

MacGregor, John S. 1957. Fecundity of the Pacific sardine (*Sardinops caerulea*) *U. S. Fish and Wildl. Serv., Fish. Bull., 57: 427–49.*

Morgan, George D. 1951. A comparative study of the spawning periods of the bluegill, *Lepomis macrochirus,* the black crappie, *Pomoxis nigromaculatus* (LeSeuer), and the white crappie, *Pomoxis annularis* (Rafinesque), of Buckeye Lake, Ohio. *Denison Univ. Bull., 42: 112–8.*

Olsen, Yngve H. and Daniel Merriman. 1946. Studies on the marine resources of southern New England. IV. The biology and economic importance of the ocean pout, *Macrozoarces americanus* (Bloch and Schneider). *Bingham Oceanogr. Coll., Bull., 9: 1–184.*

Raney, Edward C. and Ernest A. Lachner. 1939. Observations on the life history of the spotted darter, *Poecilichthys maculatus* (Kirtland). *Copeia, 1939: 157–65.*

Svärdson, Gunnar. 1949. Natural selection and egg number in fish. *Rept. Inst. Freshw. Res., Drotningholm, 29: 115–22.*

Tinbergen, N. 1953. Social behavior in animals. *London, Methuen and Co., Ltd.*

Vessel, Matt F. and Samuel Eddy. 1941. A preliminary study of the egg production of certain Minnesota fishes. *Minn. Bur. Fish. Res. Invest. Rept., 26: 1–26.*

Winn, Howard E. 1958A. Observations on the reproductive habits of darters (Pisces-Percidae). Amer. Midl. Naturalist, 59: 190–212.

———. 1958B. Comparative reproductive behavior and ecology of fourteen species of darters (Pisces-Percidae). *Ecol. Monogr.,* 28: 155–91.

Yuen, Heeny S. H. 1955. Maturity and fecundity of the bigeye tuna in the Pacific. *U. S. Fish and Wildl. Serv., Special Sci. Rept., Fisheries, 150, 1–30.*

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Migration of the Croaker, *Micropogon undulatus*[1]

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THE croaker, *Micropogon undulatus*, has declined appreciably in abundance since 1945 (Haven, 1957), but is still the most important food fish taken in Chesapeake Bay. Movements of postlarval and juvenile croakers from the ocean to the estuaries, and their return to the ocean as yearlings, have been described by Wallace (1940) and by Haven (1957). In comparison, the migratory pattern of adult croakers is imperfectly known, although their movement into the Bay in spring and their return to the ocean in fall has been reported (Hildebrand and Schroeder, 1928; Wallace, 1940). The southern limit of the winter migration, the return movement in spring, and the ages and numbers of fish involved have been based on observations of the fisheries and on limited tagging experiments (Pearson, 1932; Wallace, 1940; and Haven, 1957).

In Chesapeake Bay, most croakers are captured in pound nets, haul seines, gill nets, and by hook and line, whereas in the ocean they are taken principally by trawls. The past history of the fishery has been characterized by wide fluctuations in abundance, and since 1945 annual Virginia landings declined from about 55 to 4 million pounds, then recovered to about 10 million pounds (Anderson and Power, 1943–1957). To the south croakers inhabit the sounds and coastal waters of North Carolina in considerable numbers, but commercial landings are considerably less than in Virginia. The largest commercial landings in recent years have been taken from the Gulf of Mexico. During certain seasons, large numbers of croakers captured in shrimp trawls in North Carolina that are too small to market as food, are sold as scrap or are discarded. Fishermen in Chesapeake Bay disapprove this "destruction" of young fish, believing that North Carolina sounds may be nursery areas for fish that later migrate northward and enter Chesapeake Bay.

MATERIALS AND METHODS

From September 1949 through October 1950 a croaker-tagging program was undertaken by the Virginia Fisheries Laboratory, in cooperation with the Chesapeake Biological Laboratory, Solomons, Maryland, and the United States Fish and Wildlife Service. Tagged croakers were released in waters of Virginia, North Carolina, and in the ocean off the Maryland-Virginia coast.

Fish were obtained from three sources: in Chesapeake Bay from commercial pound nets, in the ocean from trawls, and in North Carolina from gill nets. Fish were placed in tubs of water, tags were attached with a minimum of delay, and all fish were released within one hour of capture. Most fish were marked with plastic Petersen disc tags ½ to ⅜ inch in diameter attached with stainless steel pins; a few were tagged with internal belly tags. Disc tags were attached between the first and second dorsal fins, about one-third of the distance from the mid-dorsal line to the lateral line. Belly tags were inserted with forceps through an incision in the abdominal cavity. Total lengths of tagged fish approximated those of fish in the commercial catch and ranged from 170 to 405 with a mean of about 258 millimeters. Of 1,340 croakers marked with disc tags (Table 1), 118 or about 9 percent, were recovered (Tables II and III). None of the 180 internal tags was returned. Areas of tagging and recovery are shown in Figures 1 and 2.

SEASONAL VARIATIONS IN MOVEMENT

All releases of tagged croakers in the York River took place within a radius of about four miles from the mouth of the river, and most were released in a more restricted area with a radius of only two miles (Fig. 1). Regardless of the relatively large release area, detailed records were kept of the exact point of individual releases, making possible accurate determination of distance and direction traveled by each recaptured fish. Migratory patterns of tagged fish varied with season and followed four major directions: up York River, up Chesapeake Bay, down York River, or southward toward the ocean (Fig. 3).

Most fish migrated upriver or up-Bay in spring and early summer, moved more or less at random in summer, and shifted downriver or down-Bay in fall. Croakers released early in September 1949 showed migratory patterns intermediate between summer and fall. The average distance traveled between release and recapture in 1950 also varied with

[1] Contributions from the Virginia Fisheries Laboratory, No. 82.

season, reaching a maximum in spring and fall and a minimum in August (Fig. 4). Most recaptures of croakers tagged in the lower York River region were in the same river a few days after release and relatively close to the tagging locality. However, returns from outside the York River and outside the tagging area were of special interest: in the ocean off the Virginia Capes 1 tag, Ocean View region 5, Hampton Roads 1, James River 1, Back River 6, Poquoson River 2, Mobjack Bay 4, New Point Light 3, Wolf Trap Light 1, and Rappahannock River 2 tags.

Returns from Croakers Tagged Outside the York River System

Recoveries from the croakers released near the center of Chesapeake Bay on April 21, 1950, showed an up-Bay movement (Table III). Of great interest were two recoveries of croakers tagged off the Maryland-Virginia coast and recaptured in the ocean south of Cape Hatteras (Table III). These add confirmation to the hypothesis of a coastwise migration to the south in late fall, deduced from the experience of the trawling fleet, and a single tag recovery mentioned by Pearson (1932).

Recaptures by Type of Gear

If it is assumed that tagged croakers are no more susceptible to capture than untagged fish, and there is no differential selectivity by gears, then recoveries should be proportional to the total catch of each gear. However, (Table IV), returns were not proportional to total catch as reported by Anderson and Peterson (1953).

Two possible explanations are suggested for the disproportionately high returns from pound nets. Fish were tagged from pound net catches and released near the nets, hence may have been more vulnerable to capture by this gear. The relatively short distance traveled by these fish (Table IV) supports this contention. Pound-net fishing is best in spring, when the fish are moving, and many recoveries were made before sport fishing reached its summer peak. Therefore, fewer tagged fish were available for capture by hook and line and other gear.

If recoveries from the haul-seine fishery are judged more reliable because the tagged fish had more time to disperse before capture, it is interesting to compare haul-seine recoveries with those recaptured in the sport fishery. If days out and miles traveled after

Table I

Details of Croaker Tagging in Virginia, Maryland, and North Carolina Waters, September 1949 to October 1950

Locality of Release	Date of Release	Number Tagged	No. of Tags Returned	Type of tag
1–3 miles SE mouth York River	Sept. 8–15, 1949	215	20	½″ Petersen
Ocean off Chincoteague and Assateague islands	Oct. 10–13, 1949	188	1	
Ocean off Chincoteague and Assateague islands	Oct. 10–12, 1949	131	0	¾″ internal belly tags
Ocean 15 miles N Assateague Island	Nov. 9, 1949	7	1	½″ Petersen
Beaufort, North Carolina, just inside Inlet	Feb. 4, 1949	40	0	¾″ belly tag
Beaufort, North Carolina, just inside Inlet	Mar. 1, 1950	9	0	
2–4 miles SE mouth York River	Apr. 19–22, 1950	138	17	⅜″ Petersen
5 miles E York Spit Light	Apr. 21, 1950	60	3	
3 miles SE and 4 miles NE mouth of York River	May 11–24, 1950	28	5	
Mouth of York River	Jun. 13–16, 1950	299	38	
Mouth of York River	Jul. 19–27, 1950	240	8	
Mouth of York River	Aug. 18–20, 1950	89	13	
3 miles SE and 4 miles NE mouth of York River	Sept. 28–29, 1950	19	6	
3 miles SE mouth of York River	Oct. 4–6, 1950	57	6	

TABLE II

RETURNS OF TAGGED CROAKERS RELEASED AT THE MOUTH OF THE YORK RIVER, VIRGINIA, 1949 AND 1950

Directions traveled by tagged fish are coded as follows: (A) up York River, (B) up Chesapeake Bay, (C) down York River, (D) southward toward the ocean, (0) traveled less than ½ mile. Gear designated as follows: (PN) pound net, (FN) fyke net, (SGN) stake gill net, (GN) gill net, (HS) haul seine, (HL) hand line, (—) gear not reported.

Date Released	Locality Tag Recovered	Days Out	Miles and Direction Traveled from Release Point	Gear
Sept. 8–15, 1949	York River	7	2 A	PN
		7	2 A	PN
		?	6 A	PN
		7	7 A	—
		2	?	—
		14	7 A	—
		?	4 A	—
		0	5 A	PN
		?	4 A	—
		2	3 A	PN
		7	6 A	—
	Back River	5	7 D	—
		5	7 D	—
		14	7 D	—
		17	7 D	—
		10	7 D	—
	York Spit Light	17	3 C	—
		6	6 C	—
	New Point Light	2	5 B	—
		1	5 B	—
April 19–22, 1950	York River	5	18 A	FN
		6	31 A	SGN
		8[1]	7 A	PN
		9[1]	10 A	PN
		6	0	PN
		6	1 A	PN
	York River	1	1 C	PN
		1	3 A	PN
		1	1 C	PN
		35[1]	30 A	GN
		1	2 A	PN
		1	2 A	PN
		11	1 C	PN
		2[2]	21 A	GN
		34	1 B	PN
		3	2 A	PN
	Poquoson River	12	6 D	PN
May 11–24	York River	1	4 D	PN
		1	7 A	PN
		26	7 A	PN
	Poquoson River	26	5 C	HL
	Rappahannock River	35	26 B	—
June 13–16	York River	20	15 A	—
		19	5 A	HL
		16	3 A	HS
		32	12 A	HL
		18	?	—
		1	?	PN
		2	1 A	PN
		9	2 A	GN
		2	1 A	PN
		21	0	PN
		1	0	PN
		2	2 A	PN
		39	20 A	HL
		8	0	PN
		4	3 A	GN
		2	3 C	PN
		2	3 C	PN
		?	?	—
		2	3 C	—
		2	0	—
	York River	3	6 C	—
		1	3 C	PN
		0	2 A	—
		6	1 A	PN
		17	3 C	HS
		1	0	PN
		0	2 A	PN
	York Spit Light	1	5 C	—
	New Point Light	3	9 B	PN
	Mobjack Bay	16	7 B	—
		1	4 B	PN
		1	6 B	PN
	Wolf Trap Light	27	15 B	HS
	Rappahannock River	20	27 B	—
	James River	6	34 D	GN
	Box at Dealers[3]	5	?	—
		2	?	—
	Fish Market, N. C.[3]	5	?	—
July 19–27	York River	23	0	PN
		9	0	HS
		10	16 A	—
		14	3 A	HS
		11	2 C	HS
		11	0	HS
		0	3[4]	HL
		18	3 C	HS
August 18–20	York River	10	3 A	HL
		9	9 A	HL
		15	1 C	PN
		11	0	PN
		15	1 C	HL

[1] Estimated time out.
[2] Tag caught, fish not seen.
[3] Probably captured in York R.
[4] Estimated distance.

TABLE II—*cont.*

Date Released	Locality Tag Recovered	Days Out	Miles and Direction Traveled from Release Point	Gear	Date Released	Locality Tag Recovered	Days Out	Miles and Direction Traveled from Release Point	Gear
		15	0	PN			2	20 D	HS
		17	0	PN			21	23 D	GN
		15	0	PN		Hampton Roads	7	13 D	PN
	York River	8	3 C	HS		Off Virginia Capes	24	24 D	HS
		15	0	PN					
		13	2 A	HL	Oct. 4–6	York River	?[5]	0	PN
		15	0	PN			?[5]	0	PN
	Back River	17	10 D	PN			0	0	PN
						Ocean View Region	?	20 D	—
Sept. 28–29	York River	?[5]	0	PN			2	18 D	HL
	Ocean View Region	1	20 D	HS		York Spit Light	7	5 C	PN

[5] Less than 4 days out.

TABLE III

RETURNS OF TAGGED CROAKERS RELEASED IN THE OCEAN, AND FIVE MILES EAST OF YORK SPIT LIGHT IN CHESAPEAKE BAY

Gear designated as follows: (PN) pound net, (—) gear not reported

Date Released	Location		Days Out	Miles Traveled	Gear
	Released	Recaptured			
Oct. 11, 1949	Off Chincoteague Island	West New River Inlet, N. C.	—	280	—
Nov. 9, 1949	Off Assateague Island	Off Hatteras Inlet, N. C.	41	250	—
April 21, 1950	5 miles east of York Spit Light	Potomac River	81	68	—
		Chesapeake Bay	51[1]	—	—
		Great Wicomico Light	24	36	PN

[1] Estimated time out.

release are reliable criteria, then the two fisheries were comparable, for both groups traveled the same mean distance and were out for equivalent periods of time (Table IV). This close agreement suggests that the sport fishery may land almost as many croakers as the haul-seine fishery, which approximated three million pounds in 1950. This estimate is based on few returns from a relatively small area, but suggests that the sport fishery for croakers is of considerable magnitude, and must be considered in attempts to estimate fishing mortality rates, total catch, and rates of exploitation.

RATES OF EXPLOITATION

A well-designed tagging program can give valuable information on the fraction of the available stock of fish that is removed by fishing. This study is of limited value for this purpose, but it is of interest to examine the estimated rate of exploitation that can be derived from the 1950 tagging at the mouth of the York River. During the study only ten percent of the tags attached in Chesapeake Bay were returned, a seemingly low figure in view of the apparently intensive fishing in the area. A probable explanation involves failure of fishermen to return all tags. Experience has shown that this creates a significant bias unless a strong effort is made to contact fishermen. Nesbit (1954) tagged about 8,000 weakfish with belly tags from 1931 to 1937, from Long Island Sound to North Carolina and recovered only about 6 percent. Walburg and Sykes (1957), on the other hand, by contacting fishermen frequently, obtained returns from more than 70 percent of tagged

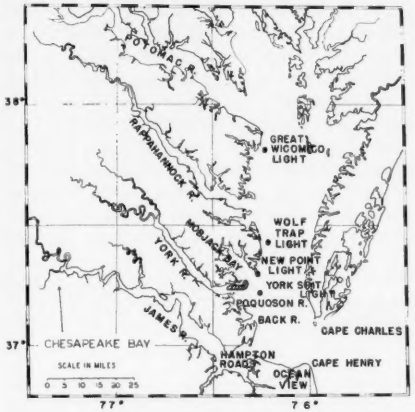

Fig. 1. Regions of croaker tagging and recovery in 1949 and 1950. With the exception of one group, all fish tagged in Chesapeake Bay were released in the shaded area at the mouth of the York River.

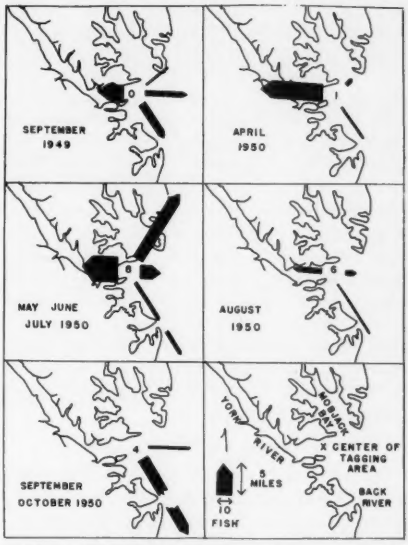

Fig. 3. Direction and mean distances traveled by croakers tagged at the mouth of the York River during 1949 and 1950. Widths of arrows are proportional to numbers of tags recovered, and lengths are proportional to mean distance traveled. Numbers in center of tagging area show numbers of fish that moved less than a mile.

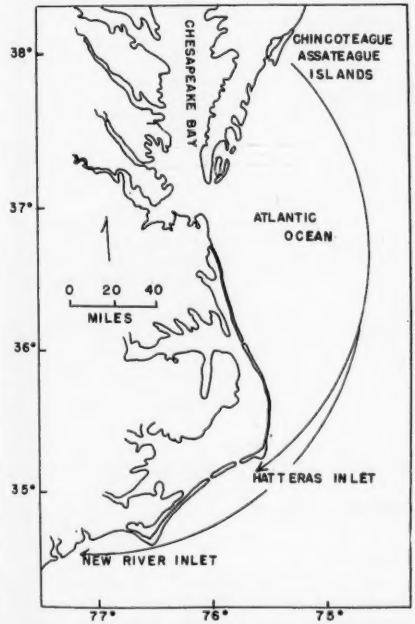

Fig. 2. Regions in the Atlantic Ocean where croakers were tagged and recovered in 1949 and 1950.

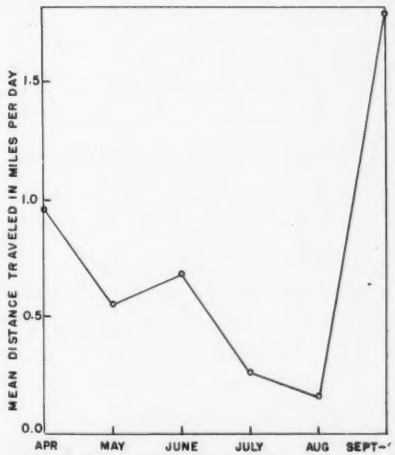

Fig. 4. Rates of croaker migration in Chesapeake Bay region in 1950, as computed from tag recoveries.

TABLE IV

NUMBER OF RETURNS, DAYS OUT AND MILES TRAVELED IN RELATION TO THE COMMERCIAL CROAKER CATCH FOR 1950

Gear	Pounds landed	Tag Returns		
		Number	Mean miles traveled	Mean days out
Pound Net	1,938,700	47	3	8
Haul Seine	3,268,200	12	8	13
Sport Fishery	—	10	8	16

shad in the James River in 1952. Although recovery of tags was probably incomplete, it is not possible to estimate the magnitude of this error.

SUMMARY AND CONCLUSIONS

In 1949 and 1950, 1,340 Petersen disc tags and 180 internal belly tags were used to tag croakers in Chesapeake Bay and North Carolina. Returns from ocean tagging with Petersen disc tags were poor, and no returns of belly tags were obtained. Most fish were tagged near the mouth of the York River; about 10 percent of these were returned by commercial and sport fishermen.

Tag recoveries indicate movement of croakers up the estuaries and up the Bay during spring, limited random movement in summer, and an oceanward migration in fall. Distances traveled were greatest during spring and fall and minimum in August. Croakers tagged off the Maryland-Virginia coast in fall migrated to waters off the North Carolina coast. No tags attached in North Carolina waters were recovered in the Chesapeake Bay region.

More tags were recovered from pound nets than from haul seines, although haul seines captured more croakers during 1950. Croakers for tagging were obtained from pound nets and released in the same area, making them especially vulnerable to recapture in this gear. Also, the greater effort exerted by pound nets in spring reduced the number of tags available for capture by other gear.

In 1950, the sport fishery captured almost as many tagged croakers as the haul-seine fishery. This suggests that the total quantity of croakers captured by sport fishermen must be very large and may have approached three million pounds in that year.

LITERATURE CITED

ANDERSON, A. W. AND C. E. PETERSON. 1953. Fishery Statistics of the United States, 1950. *U. S. Govt. Printing Office, Washington 25, D. C.: 492 pp.*

——— AND E. A. POWER. 1943–1957. Fishery Statistics of the United States, 1945–1955. *U. S. Govt. Printing Office, Washington 25, D. C.*

HAVEN, D. S. 1957. Distribution, growth, and availability of juvenile croaker, *Micropogon undulatus*, in Virginia. *Ecology, 38: 88–97.*

HILDEBRAND, S. F., AND W. C. SCHROEDER. 1928. Fishes of Chesapeake Bay. *Bull. U. S. Bur. Fish., 43: 366 pp.*

NESBIT, R. A. 1954. Weakfish migration in relation to its conservation. *U. S. Fish and Wildl. Serv., Spec. Sci. Rept., 115: 81 pp.*

PEARSON, J. C. 1932. Winter trawl fishery off the Virginia and North Carolina coasts. *U. S. Bur. Fish., Inv. Rept., 10: 31 pp.*

WALBURG, C. H., AND J. E. SYKES. 1957. Shad fishery of Chesapeake Bay with special emphasis on the fishery of Virginia. *U. S. Fish and Wildl. Serv., Res. Rept., 48: 26 pp.*

WALLACE, D. H. 1940. Sexual development of the croaker *Micropogon undulatus*, and distribution of the early stages in Chesapeake Bay. *Trans. Am. Fish. Soc., 70: 475–482.*

VIRGINIA FISHERIES LABORATORY, GLOUCESTER POINT, VIRGINIA.

A New Shark of the Family Squalidae from the Carolina Continental Slope

STEWART SPRINGER

A SMALL shark caught in an otter trawl off Cape Fear, North Carolina, in 200 fathoms during an exploratory cruise of the Bureau of Commercial Fisheries vessel DELAWARE is referred here to the genus *Deania*. Species of *Deania* have been recorded from deep water off Portugal, Madeira, Natal, Australia, Philippine Islands, and Japan. In a review of the suborder Squaloidea, Bigelow and Schroeder (1957) recognized the validity of four or five of the nine species of *Deania* described to that year. The Carolina specimen

differs in several important respects from any of these species and is described here as new.

Genus *Deania*

Deania Jordan and Snyder, *Proc. U. S. Nat. Mus., 25, p. 80,* 1902, type species *Deania eglantina* Jordan and Snyder by monotypy.

Deania elegans sp. nov.

Fig. 1.

HOLOTYPE.—U.S.N.M. 159603, a young male 315 mm. in total length, taken in about 200 fathoms, Feb. 23, 1958, by the Bureau of Commercial Fisheries exploratory vessel DELAWARE at 34 degrees 40 minutes north, 75 degrees 32 minutes west (on the continental slope off North Carolina), in an otter trawl drag.

RANGE.—Known only from the holotype.

DIAGNOSIS.—This species has a strongly compressed body, a condition it shares with *Deania profundorum* (Smith and Radcliffe) of the Philippines (described in Smith 1912) but apparently not with other species of the genus which, if the body shapes are mentioned at all in descriptions, are said to be fusiform or moderately compressed. Furthermore, *elegans* has a strong keel or noticeable flap of skin medially between the pelvics and the lower caudal lobe. This is another characteristic in common with *D. profundorum* but which is absent from the type of *D. eglantina* Jordan and Snyder (1902), and is not mentioned in descriptions or shown in figures of other species. The new species probably should be grouped with *profundorum* in the subgenus *Nasisqualus* Smith and Radcliffe (see Fowler 1941) in spite of differences in the form of the teeth which are extreme for the genus. In *profundorum*, the single cusps of the upper jaw teeth are erect, or nearly erect while in the new species, *elegans*, the cusps of the upper jaw teeth are strongly angled centrally and nearly recumbent laterally. The new species has a more elaborately shaped head (see Fig. 1, B and C) and a longer snout than any other species of the genus. It is fairly evident, however, that *elegans* resembles *profundorum* more closely in head shape than any other member of the genus.

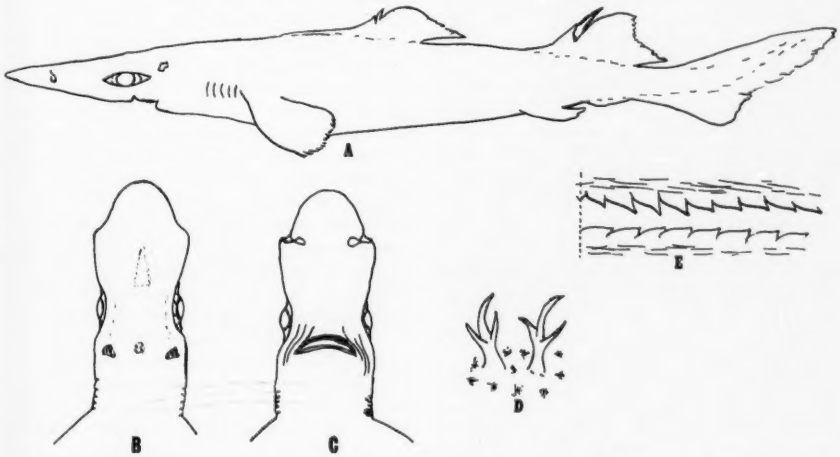

Fig. 1. *Deania elegans* **sp. nov.**, type, a young male 315 mm., A.—Lateral view; B.—Dorsal view of head; C.—Ventral view of head; D.—Dermal denticles; E.—First 8–10 rows of teeth of left side from symphysis (dotted line).

The denticles of *elegans* are irregular tridents similar to those of other members of the genus except *D. quadrispinosa* (McCulloch). The denticles of *elegans*, however, are sparsely set, unlike the dense distribution in either of the types of *profundorum* or *eglantina*.

The upper jaw teeth of *elegans* are oblique, strongly angled toward the corners of the mouth, more so than in any other species of the genus. The lower jaw teeth have recumbent cusps. Sexual dimorphism in tooth shape among species of *Deania* is discussed

by Bigelow and Schroeder (1957) and may be a factor to consider in their identification. The condition in the single specimen of *elegans*, however, is extreme for the genus.

The type of *elegans* appears to be a very young male and shows a mark which may be the yolk-sac scar. The claspers have only about 3 mm. of their lengths free from the pelvics. The type of *profundorum* is 440 mm. long (Smith 1912) and the specimen has well developed claspers. Garman (1913) made the reasonable assumption that the type of *profundorum* is a mature male; *elegans*, then, is presumably a somewhat larger species than is *profundorum*.

Regan (1908) regarded *eglantina* as not separable from the Atlantic *calceus* Lowe but Bigelow and Schroeder (1957) defer judgment as to the status of these forms.

Proportional measurements for the definition of species of *Deania* appear to be of questionable value since comparatively few specimens are known. Regan (1908) points out that there is considerable variation in some of the described species. The new species, however, is to be readily diagnosed from the unique shape of the head and is also separable from *profundorum* with which it shares the presence of an anal flap, by the shape of the teeth, density of the denticle distribution, and probably by the size indicated for adults.

DESCRIPTION.—*Color* (from fresh specimen):—light shark-gray above, lighter below; tip of snout edged with black anterior to the nasal flare, black color stronger below; dorsal area above the nostrils and over the nasal capsule dark; supraocular areas dark; a dark pineal spot about the size of the spiracle midway between the spiracles; dark areas above the gill chambers; a whitish area on the top of the snout, narrowly triangular, its base at the forward edge of the cranium, its apex at a line across the posterior edges of the nostrils; pectorals narrowly edged with black only along their anterior margins; caudal narrowly edged with black above and below but not along distal margin; first and second dorsals similarly marked with their forward edges (in advance of spines) edged with black, a black area or spot posterior to spines but extending only about halfway to posterior tips of fins; spines white; pelvics faintly edged with dusky; pupil green; inside of mouth, gill cavity, and spiracles dull bluish black.

Head and body.—Body strongly compressed posterior to the pectoral girdle; head flattened; the snout greatly produced, its length in front of mouth nearly twice as great as the distance from the corners of the mouth to the insertion of the pectorals, snout wider at the nostrils than between the eyes, the tip of the snout regularly rounded in advance of the nostrils where it abruptly widens; nostrils large, almost transverse, each with well defined lateral and medial orifices separated only by free flaps, the outer orifices directed approximately forward, the inner downward, a small flap in advance of the inner orifice; orbits elongate, more than twice as long as high, their lengths approximately equal to the width of the mouth and only slightly greater than one-third the length of the snout; dark-adapted pupils large, round, entirely in advance of the mouth; spiracles large, subtriangular, opening dorsally and located very little posterior to a vertical through the corners of the mouth; mouth nearly transverse and very little arched; a deep groove around the corners of the mouth and extending on either side of the upper jaws about half the distance toward the symphysis, the grooves overlaid by folds of skin, the region immediately in front of the mouth and along the folds of skin with pore-like organs visible to the naked eye; lateral line plainly visible, curving downward below the posterior half of the second dorsal fin; five gill slits of about equal length, lateral, and all in advance of the insertion of the pectorals; total number of vertebrae 113 ± 2; otoliths prominent in x-ray photographs, elongate, lengths nearly equal to the diameter of the spiracle.

Fins generally weak, scaleless along their distal margins; pectorals lobe-like, their free inner angles rounded and not produced but their inner margins slightly longer than their outer margins, inserted immediately posterior to the fifth gill slit at the median level, their free tips not extending backward as far as a vertical through the first dorsal spine; pelvics rather small, inserted slightly in advance of the second dorsal spine; a strong median ridge starting over the axil of the pectoral extending to the first dorsal spine and continuous with first dorsal fin, first dorsal rather low, its height less than the length of its attached base; no ridge on the back between the dorsals, first dorsal spine nearer the origin of caudal fin lobe than the tip of the snout but nearer the tip of the snout than the tip of the caudal fin; second dorsal fin larger than the first dorsal, its posterior tip reaching the base of caudal, the end of its base over the insertion of the lower lobe of the caudal; second dorsal spine inserted over

posterior portion of base of pelvics; no anal fin but a noticeable ridge or skin flap in its place.

Spines, teeth, and denticles.—Both dorsal fins with spines, their points directed upward and backward, the second dorsal spine much larger than the first, its free length about 3 times the free length of the first spine, both spines pointed, approximately triangular in cross-section, with shallow and broad grooves in the two forward sides, the first dorsal spine not as high as the fin, the second dorsal spine about as high as the fin; upper jaw teeth in 12 plus 1 plus 13 rows, the median tooth small with an erect cusp, the lateral teeth with triangular cusps strongly angled toward the corners of the mouth, not serrate, those of the 6th to the 12th or 13th row similar to the lower jaw teeth; lower jaw teeth in 12 plus 12 rows, no small symphyseal teeth, edges smooth, their points directed laterally with their inner margins forming a nearly continuous cutting edge (*Squalus*-like); denticles irregular tridents, a few with four prongs, the central prong usually strongest, with weak keels on some of the prongs, widely spaced, erect, the tips of the longer prongs usually with the tips directed posteriorly, pigment spots between denticles.

Proportional dimensions of type in percent of total length (315 mm).—Snout in front of nostrils 5.1; snout in front of mouth 18.1; orbit, horizontal diameter 6.3; mouth breadth 6.7; distance between inner ends of nostrils 5.1; upper caudal fin margin 22.2; lower caudal fin anterior margin 11.7; tip of snout to 1st dorsal spine 41.3; tip of snout to origin upper caudal 77.7; tip of snout to insertion pectorals 27.6.

REMARKS.—One other shark, a specimen of *Etmopterus bullisi* Bigelow and Schroeder, was taken in the same drag with the new species and no other sharks were obtained in the several tows made at depths of 200 fathoms by the DELAWARE off the Carolina coast. The appearance of new species of sharks from depths greater than 100 fathoms is not surprising. The shark fauna in these depths in the Gulf of Mexico, Caribbean, and the adjacent Atlantic appears, from recent collections made by exploratory vessels of the U.S. Fish and Wildlife Service, to be large and varied. Species representing genera hitherto known only from the Eastern Atlantic or the Indo-Pacific region are to be expected.

LITERATURE CITED

BIGELOW, HENRY B. AND WILLIAM C. SCHROEDER. 1957. A study of the sharks of the suborder Squaloidea. *Bull. Mus. Comp. Zool. 117, No. 1, pp. 1–150, pls. 1–4.*

FOWLER, HENRY W. 1941. Contribution to the biology of the Philippine archipelago and adjacent regions. *Bulletin U. S. Nat. Mus. 100, Vol. 13, pp. 1–879.*

GARMAN, SAMUEL. 1913. The Plagiostomia. *Mem. Mus. Comp. Zool. 36, 1–515, pls. 1–75.*

JORDAN, D. S. AND J. O. SNYDER. 1902. Descriptions of Two New Species of squaloid sharks from Japan. *Proc. U. S. Nat. Mus. vol. 25, pp. 79–81.*

REGAN, C. T. 1908. A synopsis of the sharks of the family Squalidae. *Ann. Mag. Nat. Hist., series 8, vol. 2, pp. 39–57.*

SMITH, HUGH M. 1912. The squaloid sharks of the Philippine archipelago, with descriptions of new genera and species. *Proc. U. S. Nat. Mus. vol. 41, pp. 677–685, pls. 50–54.*

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The Inheritance of the Color Phases of *Plethodon cinereus*

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ONE of the most conspicuous of the small forest leaf-litter inhabiting animals of eastern North America is the red-backed salamander, *Plethodon cinereus* (Green, 1818). This species is well known for its striking pattern dimorphism. Its two color phases were originally described as distinct species by Green, who in the same paper named the unstriped or dark phase *Salamandra cinerea*, and the striped or red-backed phase *Salamandra erythronota*. For a number of years the two color phases were regarded as separate species; later as varieties and subspecies; but are now universally recognized as merely pattern variants of the same species. The same type of pigmentation dimorphism occurs in several other species of related plethodontid salamanders.

In some portions of the range of this salamander, the frequency of the two pattern types is approximately the same, while in other localities one or the other phenotype

is more abundant. In many places the dark phase is apparently absent, whereas in a few areas the red-backed phase may be extremely rare or absent. Thurow (1955) has presented a detailed analysis of geographic variation in the frequency of the color phases and has reviewed most of the pertinent literature.

All attempts to study the inheritance of these color phases by laboratory breeding experiments have thus far proved unsuccessful. Occasionally a female that has been collected just prior to the egg-laying period has deposited eggs in captivity (Lynn and Dent, 1941). In our laboratory, only one embryo has been successfully reared from such clutches. Attempts to induce egg-laying by the transplantation of gravid female *Plethodon* pituitary glands have been moderately successful, but none of the eggs obtained thus far have developed.

The purpose of the present study was to obtain information on the mode of inheritance of the two color phases from parent-offspring data. Two authors, Burger (1935) and Rabb (1955) have reported mixed clutches with both striped and unstriped individuals in the same brood. Care should be taken not to draw conclusions on the color phases of embryos, however, for in specimens incubated in the laboratory, it has been noted that melanophores sometimes do not develop in the dorsal region of the unstriped phase until a few days before hatching. Several embryos that were first classified as "striped" have later hatched into unstriped individuals.

There is considerable variation in the amount of red pigment visible on the dorsum of red-backed salamanders. In some large specimens there is a great deal of diffusion of black pigment into the stripe region, so that the stripe is barely visible over most of its length. Phenotypically these specimens resemble the unstriped phase much more than the striped phase. However, it is believed that the diffusion of melanophores into the stripe of these specimens increases with age, and that they are initially striped. All hatchlings may be easily classified as striped or unstriped; even those offspring of mothers with a large amount of black pigment in the dorsal stripe region have clearly defined stripes. For this reason, all specimens with any red pigment in the striped region are here classified as striped.

The number of eggs deposited by the red-backed salamander is small, ranging from 1 to 14 (Lynn and Dent, 1941; see also Bishop, 1941, for other references). It is therefore difficult to obtain sufficient data from a single brood to distinguish between the common Mendelian ratios 3:1 and 1:1, as is possible with many other amphibians. Moreover, the salamanders of the family Plethodontidae practice internal fertilization so it is impossible to know the number of males with which a single female has mated. Superfecundation could result in many different phenotypic ratios, even if simple Mendelian inheritance is operating. The female parent apparently remains with her eggs from the time they are deposited until after the young have hatched, so that her phenotype can be readily determined.

There are several genetic mechanisms which may account for the presence of two contrasting phenotypes in a population. It is also possible that the development of these color phases may be affected by varying environmental conditions. Incomplete penetrance might also be operative. Without carefully controlled breeding experiments, it is at present impossible to rule out any or all of the known genetic and environmental factors which might influence the production of the dorsal pattern of these salamanders. In the present analysis, the simplest genetic mechanism that would explain the observed dimorphism has been investigated. This is the presence of a single pair of alleles with dominance. The parent-offspring data will be analyzed to determine whether the theory of a striped dominant gene or an unstriped dominant gene offers a more satisfactory working hypothesis to explain the inheritance of these traits if a single gene difference is involved. This analysis assumes that the conditions (panmixia, no selection pressure, etc.) which are necessary for the Hardy-Weinberg Law to be applicable, are met in the salamander populations concerned.

Figure 1 shows the proportion of striped and unstriped offspring expected from striped mothers in various populations when one gene is dominant. It may be seen that the expected proportion of striped offspring from striped mothers is about the same in most populations, regardless of whether the striped gene is dominant or recessive. Indeed, the same proportion is expected when there is a 50:50 phenotypic ratio in the population. Only in populations in which the striped phase is rare is it possible to distinguish between the alternative hypotheses on the basis of mother-offspring data. Similarly (see Fig. 2), the frequency of the two color phases ex-

pected in the offspring of unstriped mothers is similar, under either theory, except in populations in which the unicolored phase is rare. For this reason an attempt was made to obtain mothers and their broods from populations in which the frequency of one of the color phases is rare.

Such a population exists on Potts Mountain, five miles NNE of the town of Mountain Lake, Giles County, Virginia. During August of 1958, large collections of *Plethodon cinereus* were made at or near the summit of this mountain and nineteen clutches of eggs were collected. Each was guarded by a single spent female. (The striped adult accompanying clutch 1958–14 escaped, so its gonads were not examined.) The first four clutches (nos. 1958–12 to 1958–15 in Table I) were taken at a locality 0.2 mile west of the top of Potts Mountain at an elevation of approximately 3800 feet. Of a total of 133 *P. cinereus* (including mothers but not their offspring) collected at this locality, 107 (80.45 ± 3.44 percent) were striped. The fifteen remaining clutches from Potts Mountain (1958–16 to 1958–30) were collected along the ridge from the highest point, where there is a fire tower, to a point 0.8 mile east of the fire tower (elevation, 4000–4120 feet). From this population, 501 (86.23 ± 1.43 percent) of a sample of 581 specimens were striped. The difference in the frequency of the striped phase in the two series is not statistically significant at the 5 percent level of significance. Similarly, there were no statistically significant linear trends in collections from different places along the 0.8 mile at the top of the ridge. Since all the samples from Potts Mountain could reasonably have been taken from the same population, the combined percentage of all specimens collected will be used in calculating gene frequencies. In all, 608 of 714 specimens from Potts Mountain were striped (85.15 ± 1.33 percent).

All of the broods collected on Potts Mountain were taken during the period from August 9–19, 1958. At this time many of the embryos were about to hatch, and some had already hatched. The female apparently remains with her young for some time after they hatch, for, on exposure of the nest, several of the newly hatched young were seen sitting or crawling on their mother's body. Hatchlings were collected on August 10 and eggs were found as late as August 18, so the hatching period extended over the entire collecting period. All the eggs hatched by September 14, 1958.

In addition, one clutch collected on July 13, 1957, is included in Table I. It was found on Hawksbill Mountain, Shenandoah National Park, Virginia, at an elevation of approximately 3500 feet. From this locality, 136 of 170 (80.00 ± 3.07 percent) of the *P. cinereus* collected were striped.

Altogether there are 20 clutches of *P. cinereus* eggs available from populations in which the frequency of the unstriped phase is low (20 percent or less). Only three of these clutches were accompanied by mothers of the unstriped phase. Of the 24 offspring from dark phase mothers, 16 or 66.67 percent are striped. These data may be compared with the expected proportion of striped offspring

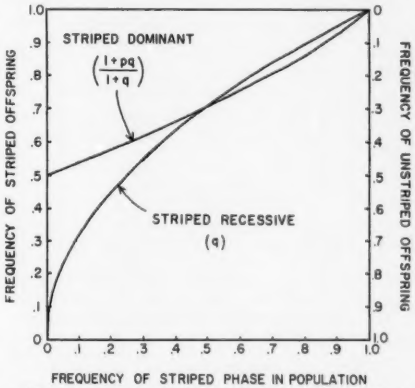

Fig. 1. The expected proportion of striped and unstriped offspring from striped females in various populations of *Plethodon cinereus* if the striped gene is dominant and if it is recessive.

from unstriped mothers in the Potts Mountain population if the striped gene is dominant or recessive (see figure 2). If the striped gene is dominant and 14.85 percent of the population is unstriped, then the frequency, q, of the unstriped gene is .3853 and the frequency of the dominant striped gene, p, is .6147. The proportion of striped offspring expected from unstriped mothers in such a population is 61.47 percent. The observed proportion in the three broods is very close to the expected if the striped gene is dominant. On the other hand, if the unstriped gene is dominant and the striped gene recessive, in a population in which 85.15 percent of the salamanders are striped, the frequency of the striped gene, q, would be .9228 and the expected percentage of striped offspring from unstriped mothers would be

TABLE I

THE NUMBER OF STRIPED AND UNSTRIPED OFFSPRING FROM CLUTCHES OF *Plethodon cinereus* EGGS COLLECTED DURING THE SUMMERS OF 1957 AND 1958, IN VIRGINIA

Locality	Frequency of striped phase in population	Clutch No.	Phenotype of female parent	No. of offspring	
				Striped	Unstriped
Hawksbill Mt.	.8000 ± .0307[1]	1957–27	Striped	7	
Potts Mt.	.8515 ± .0133	1958–12	Striped	11	
		1958–13	Unstriped	5	5
		1958–14	Striped	8	
		1958–15	Unstriped	3	3
		1958–16	Striped	9	
		1958–17	Striped	3	
		1958–18	Striped	6	
		1958–19	Striped	6	
		1958–20	Striped	4	
		1958–21	Striped	3	
		1958–22	Striped	7	
		1958–23	Striped	6	1
		1958–24	Striped	3	3
		1958–25	Striped	5	
		1958–26	Striped	5	1
		1958–27	Striped	9	
		1958–28	Striped	2	1
		1958–29	Unstriped	8	
		1958–30	Striped	8	

[1] One standard error of the mean.

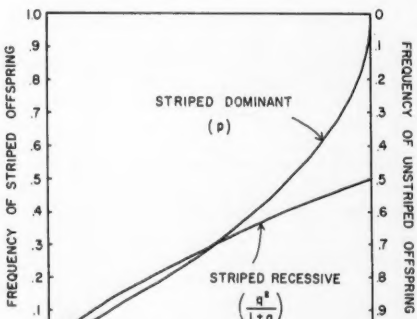

Fig. 2. The expected proportion of striped and unstriped offspring from unstriped females in various populations of *Plethodon cinereus* if the striped gene is dominant and if it is recessive.

44.29 percent. For the derivation of the formulae used to calculate these expected proportions, see Li (1955: 17). Clearly, the data fit the theory that the striped gene is dominant better than they do the alternative hypothesis. It is not easy to apply statistical tests to these expected and observed proportions, since each parent-offspring pair is not an independent parent-offspring observation. The hatchlings within each clutch have the same female parent and perhaps also the same male parent, so that only the three different clutches are independent of one another. There are not enough independent clutches to comprise an adequate sample to evaluate statistically.

One of the broods, 1958–29, is very significant. An unstriped mother produced a clutch of eight striped offspring. If the unstriped gene is dominant and a heterozygous female mated with a recessive striped male, the probability of obtaining the observed ratio is 1 in 256 (.0039). If a heterozygous female mated with a heterozygous male, the probability of obtaining such a clutch is 1 in 65,536 (.000015). In a population with 85.15 percent of the animals striped, the first type of mating involving a heterozygous unstriped mother would be expected to occur 85.15 percent of the time and the mating between two heterozygotes would occur 14.34 percent of the time. (The matings between a heterozygous female and a homozygous unstriped male, or those involving any homozygous unstriped females would be of no concern because no striped offspring would result.) Thus if the unstriped gene is dominant, the probability of an unstriped mother having a brood of eight striped offspring would be .0033. On the other hand, if the striped gene is dominant, a homozygous recessive unstriped female would be expected to have a brood composed entirely of striped offspring every time she mated with a homozygous dominant striped male. In the population considered here 37.79 percent of the total population would be expected to be homozygous for the striped gene, and 47.37 percent of the total population would be expected to be heterozygous. This would mean that about 44 percent of the broods containing striped offspring would be expected to be comprised entirely of striped offspring, provided that each female had mated with only one male. The hypothesis that the striped gene is dominant is clearly a more likely one, based on the observed data, than its alternative of a striped recessive gene.

If an unstriped female mated with a heterozygous striped male, then a 1:1 ratio of striped to unstriped offspring would be expected. Actually the two mixed clutches from unstriped female parents each had exactly a 1:1 ratio of striped to unstriped offspring.

If a heterozygous striped female mated with a single heterozygous male, then about 75 percent of their offspring should be striped. This would be the most frequent type of mating that would produce mixed broods. A 1:1 ratio would be expected when a heterozygous striped female mated with an unstriped male, but this mating would be far less frequent in the population concerned. In mixed broods from striped mothers, 16 of the 22 (72.73 percent) offspring are striped (see Table I). If the striped phase is recessive, on the other hand, a 1:1 phenotypic ratio would be expected in mixed broods, provided each female mates with only one male. If females mate with more than one male, however, a greater proportion of striped offspring would be expected.

Blanchard (1928) failed to find a sexual difference in the proportion of striped and unstriped specimens in Michigan populations of *P. cinereus*. Similarly, there is no evidence of any significant sexual dimorphism in the proportion of striped and unstriped phases in the Potts Mountain, Virginia, population. Of 314 females, 263 (83.76 percent) are striped, and of 400 males, 345 (86.25 percent) are striped.

If the striped gene is dominant, in a population where 85.15 percent of the salamanders are striped, striped mothers would be expected to have 89.28 percent striped offspring. If the striped gene is recessive, striped mothers in the same population would be expected to have 92.28 percent striped offspring. The actual data on 16 Potts Mountain broods from striped mothers show 95 of 101 (94.44 percent) of the offspring are striped. These data fit either hypothesis, so their main significance is their support of the theory that a single pair of alleles with dominance is responsible for the pattern dimorphism in *Plethodon cinereus*. Further analysis of the broods of striped mothers is possible, but would involve an uncertain aspect of the reproductive biology of this species, since it is not known with how many males a single female may mate. The expected ratios within families are somewhat different, depending on how many male parents contribute sperm toward each litter. Many more broods must be obtained before it will be possible to throw some light on this aspect of the social behavior of this species.

In summary, it may be concluded that if a single pair of genes with dominance and complete penetrance is responsible for the pattern dimorphism in the dorsal striping of *Plethodon cinereus*, all available evidence favors the hypothesis that the gene for striping is dominant to the gene for the unicolored unstriped condition.

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Literature Cited

Bishop, Sherman C. 1941. The salamanders of New York. *Bull. N. Y. State Museum (324): 1–365, figs. 1–66.*

Blanchard, Frank N. 1928. Topics from the life history and habits of the red-backed salamander in southern Michigan. *Amer. Nat., 62: 156–64, figs. 1–4.*

Burger, J. Wendell. 1935. *Plethodon cinereus* (Green) in eastern Pennsylvania and New Jersey. *Amer. Nat., 69: 578–86.*

Green, Jacob. 1818. Descriptions of several species of North American Amphibia, accompanied with observations. *Jour. Acad. Nat. Sci. Phila., 1 (2): 348–59.*

Li, Ching Chun. 1955. Population genetics. *University of Chicago Press: 366 pp., 82 figs.*

Lynn, W. Gardner, and James N. Dent. 1941. Notes on *Plethodon cinereus* and *Hemidactylium scutatum* on Cape Cod. *Copeia (2): 113–4.*

Rabb, George B. 1955. Observations on the identity of the salamander *Plethodon huldae*. *Copeia (3): 261–2.*

Thurow, Gordon R. 1955. Taxonomic and ecological studies on the zig-zag salamander (*Plethodon dorsalis*) and the red-backed salamander (*Plethodon cinereus*). Ph. D. dissertation, Indiana University: 250 pp., 18 figs.

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Classification of the Serpentes: A Critical Review

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IN THE past, animal groups without extensive fossil records have invited considerable speculative effort toward a solution of their phylogeny and the interrelations of their members. Among vertebrates the modern amphibians and snakes are outstanding in the paucity of fossil material suitable for classificatory aid; even the birds have some relevant fossils preserved. In the class Amphibia, neither the Apoda with only about 70 species nor the Caudata with perhaps 250 offer particularly complex classificatory problems. Only the Salientia presents the systematist with a number of species great enough (about 2500) and fossil record scanty enough to approach the taxonomic tangle offered by the 3000 or more species of serpents which to date lack a single fossil specimen that is phylogenetically meaningful.

It is, perhaps, this same lack of precise paleontological information that has restrained most modern herpetologists from attempts to improve on the phyletic schemes advanced by workers of the last century. The diverse viewpoints expressed by four recent works (Schmidt, 1950; Bellairs and Underwood, 1950; Johnson, 1956; and Romer, 1956), however, indicate that the interrelations of the Serpentes are far from settled. Further, reference to these papers and to others shows clearly that, as yet, too few morphological characters have been considered, and that too few representatives of the recognized systematic categories have been examined to give any proper basis for good taxonomic decision.

This paper was first prepared in 1954 as a critique of the papers by Schmidt, and Bellairs and Underwood, and was presented at the annual meeting of the Society for the Study of Evolution in 1955. The additional information provided by the work of Johnson (1955, 1956) and the rather controversial phyletic scheme offered by Romer (1956) have caused a considerable addition to and revision of the original draft. The present paper, then, attempts to point up the differences between the phylogenetic schemes proposed by the above workers, to analyze and redefine the major categories, and to suggest some areas where further morphological information is particularly needed.

BACKGROUND

The recent literature pertinent to a study of snake phylogeny is much scattered. Some of the most important works are concerned with faunal segments (e.g., Smith, 1926, sea snakes; Dunn, 1928, American colubrids; Bogert, 1940, African colubrids; Smith, 1943, Indian snakes). Other important information is found in surveys of various groups using restricted morphological features (e.g., Mosauer, 1935, body musculature; Haas, 1930, *et seq.*, jaw musculature; Walls, 1942, eye; Bogert, 1943, dentition; Smith and Warner, 1948, hyobranchium; Brongersma, 1951, lungs; Johnson, 1955, 1956, vertebrae). Only three recent papers have been primarily concerned with the broader aspects of snake evolution. Of these Mahendra (1938) proposed a phylogeny in opposition to Boulenger's, Schmidt (1950) was concerned mainly with the adaptational aspects of the group, and Bellairs and Underwood (1951) were concerned more with its origin. Recently important discussions of snake phylogeny have been hidden by incorporating them with other material, and contributions to this subject have appeared under such innocuous and apparently irrelevant titles as "Affinities of the anguinomorphan lizards," (McDowell and Bogert, 1954), critiques thereof (Underwood, 1957a), "Osteology of the reptiles" (Romer, 1956), and "On lizards of the family Pygopodidae" (Underwood, 1957b).

Due to the different methods of approach and to the uneven scope of the various works, there is much disagreement in conclusions. This is not unexpected, but more unfortunate is the prevalence of contradictory statements on snake morphology. One of the greatest stumbling blocks to a proper assessment of snake phylogeny is still the extensive ignorance of the internal structure of even the most common snakes. It may be said truthfully that no snake has yet received intensive anatomical treatment and that most species are still known only by their external features. Even the rare reptile *Sphenodon* is far better known, morphologically, than any species of snake. The few internal characters thus far examined are known from so few snakes that it is still not possible to

evaluate the significance of their observed variations.

Status of the Serpentes

A new feature in reptilian classification suggested by Schmidt (1950) was the elevation of the long-standing suborder Serpentes to ordinal rank. This usage (Schmidt, 1953) has recently been supported by Underwood (1957b: 241), together with the proposal of several new higher categories. Schmidt (1950: 79) suggested that the Serpentes holds the same relation to the Sauria (lizards) as the classes Aves and Mammalia do to the class Reptilia: that they are all merely highly developed sections of their respective groups and, therefore, that there is as much reason to recognize the serpents as separate from the lizards as there is to separate the two latter as classes from the Reptilia. Underwood (1957b: 241) also emphasizes that "the radiation of either lizards or snakes is broadly equivalent to that of several orders of mammals."

An obvious difference between the two situations not considered by either of these workers, however, is that birds and mammals, in addition to being greatly expanded reptilian orders, have acquired characteristics not found in any modern reptile, and which so far as known did not occur in any extinct reptile outside the lines leading toward these classes. Large brains, unpaired aortic arches, and feathers or hair and mammary glands are well-known examples. These features are unique to these groups, and members of these classes may be identified by one or more of these characteristics. Such decisive separation is also true of other currently recognized orders of the Reptilia. Serpents, on the other hand, have no special characteristics of their own and must be differentiated from the lizards by combinations of characters, each of which is a specialization also found in some members of one or more lizard groups (Table I). An entire family (Typhlopidae) has such a combination of lizard and snake characters that its proper allocation is still in doubt (*vide infra*). Neither does it seem likely that the Serpentes, with 80 per cent of its members in a single family (Colubridae), is morphologically equivalent to several mammalian orders.

Conversely, the consistent loss of the lower (jugal-quadratojugal) temporal arch, the unique copulatory apparatus of paired hemipenes, and the presence of a transverse cloacal opening combine to make the Squamata one of the best defined of reptilian orders. Underwood's (1957b: 241-42) alternative of making the Squamata a superorder with the consequent changes in other related categories appears unduly complex, and gives no clear picture of the presumed relationships. It is here suggested that the order Squamata be retained intact so as to give the proper perspective of the close relationship between its two subordinal groups, the Sauria and the Serpentes, and the relationship of the entire order to the Rhynchocephalia.

Generalized Versus Specialized Characters

The suggestion of superfamilial categories by Hoffstetter (1939a), Smith and Warner (1948), and their use and definition by Romer (1956), revives the overall question of serpent phylogeny. Are the categories included by the superfamilial names actually phyletic units or are they merely adaptive? The selection of the most primitive snake families by Mahendra (1938: 354, Typhlopidae and Leptotyphlopidae), by Schmidt (1950: 80, Boidae), and by Bellairs and Underwood (1951: 229, Aniliidae) points up considerable differences in opinion on snake phylogeny. These differences of opinion rest on widespread uncertainty as to what the primitive characteristics of the Serpentes are, and which of the presumed primitive characteristics should be given the most phyletic weight.

Bellairs and Underwood (1951: 230) listed seven characteristics as "those regarded as primitive." These are:

1) jaw skeleton fairly firmly united with brain case, and short, giving relatively narrow gape;
2) contact or suture between premaxilla and maxilla;
3) coronoid present;
4) teeth on premaxilla;
5) pelvic rudiments present;
6) left lung relatively large;
7) ventral scales not enlarged to form gastrosteges.

Actually only four of these characters are unquestionably a direct inheritance from the lizard-ancestor, and thus definitely "primitive." These are characteristics 3, 4, 5, and 6. The other characters appear in some of the presumably "primitive" families of snakes, but some doubt may be expressed as to

whether they are primitive (i.e., derived from the ancestral form, which is as yet unknown) or specializations toward life in some particular habitat (e.g., burrowing modifications). Since blind acceptance of these presumed characteristics would inevitably lead to a search for the primitive snake family among burrowing groups, some discussion of the characters seems desirable.

TABLE I

THE APPEARANCE OF CERTAIN MORPHOLOGICAL CHARACTERISTICS IN SNAKES AND LIZARDS

Character	Serpentes		Sauria	
	Typical	Exceptions	Typical	Exceptions
1. Limbs	Absent	Pelvic appendages present in Boidae, Aniliidae, Leptotyphlopidae, Typhlopidae	Present	Pectoral appendages lost in *Anelytropsis;* most Amphisbaenidae
2. Eyelids	Absent	None	Present	Absent in Gekkonidae, Xantusiidae, Pygopodidae; some Scincidae
3. External ear	Absent	None	Present	Absent in *Holbrookia,* some *Phrynosoma, Lanthanotus,* Amphisbaenidae
4. Ventral scutes	In single row	Uropeltidae, Leptotyphlopidae, Typhlopidae, Aniliidae, some Hydrophiinae	In several rows	None
5. Zygosphenozygantral vertebral articulating surfaces	Present	None	Absent	Present in most Varanoidea; many Iguanidae
6. Connection of mandibular rami	Ligamentous	None	Sutural	Ligamentous in most Varanoidea
7. Anterior braincase	Closed	None (secondarily fenestrated in large-eyed Colubridae)	Open	Closed in Amphisbaenidae, Dibamidae
8. Epipterygoid	Absent	None	Present	Absent in some Agamidae; Chameleonidae; Amphisbaenidae, Dibamidae
9. Jugal	Absent	None	Present	Absent in Gekkonidae, Pygopodidae
10. Tongue	Elongate, retractile	None	Short nonretractile	Elongate and retractile in Anguinomorpha, Teiidae
11. Functional lungs	One	Two in *Xenopeltis,* most Boidae	Two	Right lung reduced or absent in Amphisbaenidae
12. Ability to regenerate tail	Absent	None	Present	Absent in Varanoidea, Amphisbaenidae, Chameleonidae

The appearance of typical snake characteristics is compared in both snakes and lizards. The summary presented here is representative of the overlap. Neither the listed characters nor the taxonomic categories is intended to be complete.

Firstly, in considering these points it should be emphasized that the two sets of characters differ in their appearance in the

families. The unquestionably primitive characteristics are not restricted to snakes that inhabit any one habitat. Thus the coronoid bone is found in the lower jaw of four burrowing families (Typhlopidae, Leptotyphlopidae, Uropeltidae, Aniliidae), in most boids (had Bellairs and Underwood recognized its presence here, their selection of the most primitive family might have been different), but not in the burrowing *Xenopeltis*. Premaxillary teeth are found in *Xenopeltis* and *Anilius* (burrowing types), as well as in several boids (e.g., *Python*, generalized terrestrial-arboreal). Pelvic vestiges are found in three burrowing families (Typhlopidae, Leptotyphlopidae, Aniliidae), and in the Boidae. This latter family includes arboreal (*Epicrates*) and semiaquatic (*Eunectes*) forms, as well as several widely divergent terrestrial types (e.g., *Eryx*, *Python*). A well-developed left lung is reported only in *Xenopeltis* and various members of the Boidae (*vide* Brongersma, 1951: Fig. 1). It should be plain from even this abbreviated discussion that these characteristics are not restricted to the inhabitants of any one habitat, nor are they found universally in the snakes of any particular habitat.

In opposition, the other set of characteristics, including the short quadrate and firmly united jaw (1), the contact of maxillary and premaxillary (2), and the absence of enlarged ventrals (7), is found only in burrowing forms and a functional reason correlated with this habit can be found for each. The firmly united jaw skeleton and shortened quadrate appear to be a part of the general consolidation of the skull in burrowing forms. The reduction and intercalation (*Xenopeltis*, Aniliidae), and final loss (Uropeltidae, Typhlopidae, ?Leptotyphlopidae) of the supratemporal bone is a correlated and parallel feature. It thus appears odd that the former was considered a generalized feature, the latter an "aberrant" one by Bellairs and Underwood (1951: 230). Similarly, the contact of premaxillary and maxillary bones, which is universal in the burrowing families (Typhlopidae, Leptotyphlopidae, Uropeltidae, Aniliidae, Xenopeltidae), is of obvious advantage in strengthening the snout for rooting through the soil. Analogous specializations are found among burrowing snakes of the more advanced families (e.g., the colubrid *Calamaria*, showing shortening of the supratemporal and quadrate plus consolidation of other skull bones, *fide* Marx and Inger, 1955: 169–71, and the elapid *Elaps*, which shows the premaxillary-maxillary contact, *fide* Bogert, 1943: 299). The reduction and eventual disappearance of wide ventral plates as distinctive elements in the direction Xenopeltidae → Aniliidae → Uropeltidae → Leptotyphlopidae may be correlated with the fact that ventral scutes are of little assistance where the entire body surface, rather than only the ventral surface, is in contact with the soil. Backward-projecting ventral scutes may actually hinder rearward movement under such circumstances. A similar tendency toward loss is shown in the highly specialized sea snakes, where the entire body, again, is in contact with the surrounding medium.

The absence of the ocular shield or "brille" as a distinctive element also has often been taken to be a primitive characteristic (e.g., Mahendra, 1938: 349–50). Walls' (1942) studies that suggested a burrowing ancestral type for snakes on the basis of eye structure appeared to corroborate this idea. However, this is another feature only found in burrowing families and it is functionally important in allowing further smoothing of the body surface in a critical area. Its absence does away with the crevices around the eye where dirt collects in those burrowing species that retain the brille (e.g., *Carphophis, Cemophora, Farancia,* which are often plowed up from burrows apparently of their own making), and thus offer more resistance to being pushed through the soil. While Walls (1942) did suggest the derivation of the snake eye from that of a burrowing animal, both his study and later ones (e.g., Bellairs and Boyd, 1947) have suggested the derivation of the brille from the brille-like window in the lower lid of a lizard ancestor, rather than its appearance *de novo* from some other head plate. Therefore, it seems that the presence of the brille should be considered a primitive feature in snakes and its loss is a burrowing specialization. Underwood (1957b: 257) apparently came to this same conclusion, although he did not specifically say so.

Another point that should not be overlooked is that these burrowing characteristics are highly and positively correlated with one another. Thus the families with the most highly consolidated skull (including loss [?] of the supratemporal and suturing of nasals with prefrontals), the Typhlopidae and Leptotyphlopidae, also have the greatest scutellational modifications, with complete loss of ventral plates, loss of brille, and extreme reduction of other head scutes (Fig. 1). Con-

versely, *Xenopeltis* which has little reduction in ventral plates also retains the brille and has the least consolidated skull among the specialized burrowers. More detailed correlations might be drawn within these broad outlines.

The presence of two "ventral plates" per body segment has been pointed out (Mahendra, 1938: 349) in the Typhlopidae, Leptotyphlopidae, and Uropeltidae as possible points of relationship between these snakes and as differentiating them from all other snakes. It should be remembered, however, that many snakes, including some boids, have two or more dorsal scales per body segment. The three mentioned families have the most extreme reduction of ventral plates found in snakes—to about the same size as the dorsal scales—and it might be considered that in these families the dorsals have merely replaced the ventrals. This idea would discount any close relationship of these families on this basis and any inexplicable separation of them from other snakes. Since ventral plates have tended to disappear as distinctive elements in other snakes where their functional reason for existence is no longer present (e.g., sea snakes), there appears to be no necessity of assuming their absence in burrowing families to be a primitive feature.

If the separation is made of features that are undoubtedly primitive and not restricted to snakes inhabiting a single habitat from those features here believed to be more accurately labeled as burrowing modifications, a generalized snake should possess the following characteristics:

Undoubtedly primitive features:

1) a coronoid bone in the lower jaw
2) pelvic elements and appendages
3) two well-developed lungs
4) teeth on premaxillary, maxillary, palatine, pterygoid, and dentary bones.

Features here suggested as primitive:

5) a differentiated brille covering the eye
6) an elongate supratemporal not intercalated in the wall of the braincase
7) an elongate quadrate, which with (6) allows a large gape
8) enlarged and differentiated ventral plates.

Such a combination of undoubtedly primitive features is found only in some members of the Boidae, so far as is known. The fact that these same snakes also possess all of the features here suggested as primitive tends to corroborate the validity of the latter.

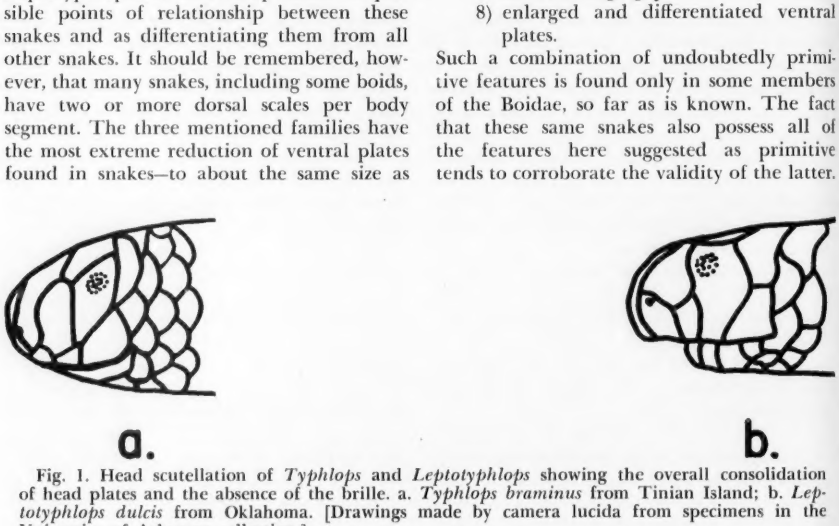

Fig. 1. Head scutellation of *Typhlops* and *Leptotyphlops* showing the overall consolidation of head plates and the absence of the brille. a. *Typhlops braminus* from Tinian Island; b. *Leptotyphlops dulcis* from Oklahoma. [Drawings made by camera lucida from specimens in the University of Arkansas collection.]

Thus the Boidae appears to hold the position as the most generalized family. This view was favored by Boulenger (1893: 2) and Schmidt (1950: 80), but not by Mahendra (1938: 355), Bellairs and Underwood (1951: 299), or Underwood (1957a: 24).

Definition of Categories

The various opinions expressed in literature, particularly in recent papers, concerning the status and relationships of the higher categories, the content and relationships of the families of snakes, and disagreements on the presence or absence of the morphological features on which these categories are based, appear to indicate the desirability of each worker defining the terms utilized. This is the only method presently available that will allow proper evaluation of the ideas on phylogeny and relationships. The definitions given below also have the purpose of bringing together various items on serpent morphology that are otherwise widely scattered

through the literature. No claim of originality is made for the definitions given here.

Order Squamata

An order of reptiles closely related to the Rhynchocephalia but characterized by: the loss of the lower, jugal-quadratojugal, temporal arch, this loss allowing a movable quadrate; the presence of paired eversible copulatory structures (hemipenes) in the male; no secondary palate; general absence of abdominal ribs (gastralia), and other large dermal plates except where bony scales fuse on the skull; vertebrae usually with procoelous centra, but those of some groups (some geckos and related lizards) are amphicoelous (see Romer, 1956: 530–31, for further definition).

Suborder Serpentes

A suborder of the Squamata distinguished from the Sauria by the following combination of characters: 1) no pectoral girdle or limbs, 2) no moveable eyelids, 3) no external auditory meatus, 4) no upper temporal arch, with loss of squamosal, 5) loss of other skull bones including lacrimal, jugal, quadratojugal, epipterygoid, and ?postfrontal, 6) braincase completely enclosed by descending processes of frontals and parietal, 7) presence of zygosphene-zygantrum articulations of vertebrae, 8) haemapophyses of caudal vertebrae not joined ventrally.

Until recently the families of the Serpentes have appeared quite well defined, but the interrelations of these families have long been matters of disagreement. Nevertheless, workers as early as Duméril and Bibron (1844) suggested superfamilial arrangements and such categories have again been suggested by Hoffstetter, (1939a: 3), Smith and Warner (1948: 192), and Romer (1956: 567). Although each has used a different set of names, all have advocated the recognition of three categories of present-day snakes, the typhlopids and leptotyphlopids in one group, the boids and less specialized burrowing families in another, and the advanced families (Colubridae, Elapidae, Hydrophiidae, and Viperidae) in the third. Hoffstetter did not define his groups other than indicating the included families. Smith and Warner used the characteristics of the hyobranchium and "other anatomical evidence," while only Romer has attempted to provide definitions for his three superfamilies. Unfortunately, these do not appear to hold true for the included units.

The Typhlopoidea as proposed by Romer (1956: 568) contains the families Typhlopidae and Leptotyphlopidae. As indicated by the definition, these families are superficially similar. However, most of their similar structures seem to be due either to the retention of primitive characteristics or to burrowing adaptations. The jaw structure in the two families is so different that convergence appears much more likely than close relationship (but *vide* Underwood, 1957a: 28). It has been suggested recently that the Typhlopidae should not be included in the Serpentes (McDowell and Bogert, 1954: 88). In any case the relationship suggested by placement in a common superfamily appears unwarranted on the basis of the available information.

The Boöidea as proposed by Romer (1956: 569) contains the recent snake families Boidae and Aniliidae, the latter so expanded and mixed by the inclusion of the previously recognized families Uropeltidae, Xenopeltidae, and some members of the Boidae, as to be almost unrecognizable. The generous use of the words "generally," "may," "frequently," and "usually" makes this definition difficult to contradict or support. However, one of the statements not so modified, "Parietal and frontal meet below the optic foramen," proves to be true in a *Python* skull at hand, but not in the skull of *Xenopeltis* or of *Cylindrophis* (Aniliidae). Recent information suggests that the boids are not so different from colubrids as the older literature would indicate (*vide infra*). Actually there appears to be more morphological divergence within the "Boöidae" than there is between it and the "Colubroidea." The recognition of superfamilies under these circumstances appears undesirable.

The families of snakes as recognized here (Fig. 2) are discussed in somewhat more detail below. The primitive and generalized family Boidae is taken first, then the specialized burrowing families, and lastly the advanced colubrids and their apparent derivatives.

Family Boidae

This family has commonly been separated into two subfamilies, which sometimes have been raised to familial rank (e.g., Schmidt, 1950: 82). The characters usually relied upon for distinguishing these groups, premaxillary teeth, postfrontal (or "supraorbital") bones, and entire or divided subcaudal scales, are not always correlated, however, and a con-

tinued search for other characters has been made. Schmidt (1950: 82) has suggested the oviparity of the "Pythonidae" as contrasting with the ovoviviparity of the "Boidae," but the breeding habits of but few species are known. It seems likely that separation on this basis would group species of unlike morphological characters and separate species that are morphologically quite similar, as hypapophyses are present on all dorsal vertebrae. He proposed the subfamily Bolyerinae on the basis of this character. Anthony and Guibé (1951, 1952) subsequently showed that these same snakes lack any trace of the pelvic girdle, that they have a hyobranchium of the "colubrid type," and that they possess a unique type of double maxillary bone. Thus, either these snakes are not boids or the possession of pelvic elements and appendages is not characteristic of this family, as commonly supposed.

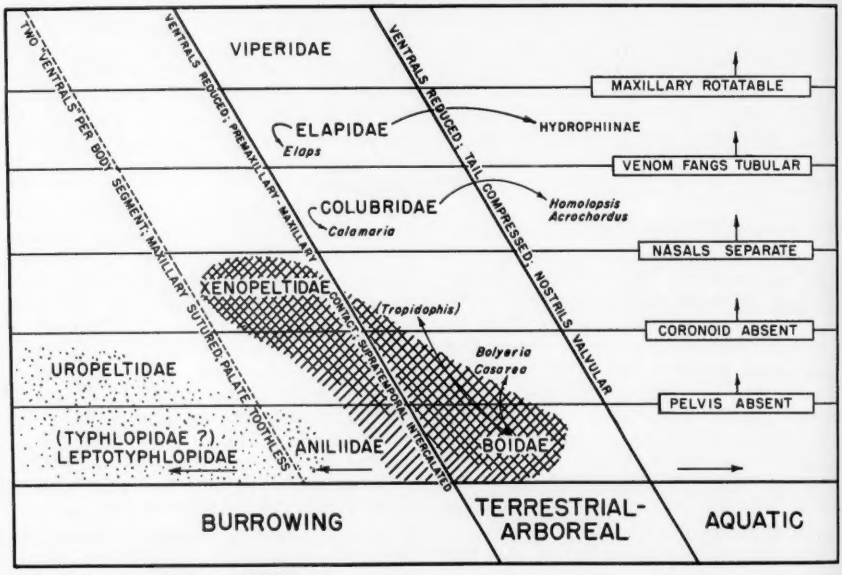

Fig. 2. Morphological relationships of families in the Serpentes. Note that the main groups of each family are well separated on the basis of these characters. The "boid" genera that, on the basis of current information, appear to break down the familial definition are indicated. Similarly, those genera of the generalized families Colubridae and Elapidae that have invaded special habitats and become modified thereby are shown. The Typhlopidae, that have a moveable maxillary bone, and the genus *Tropidophis*, that has pelvic elements, do not fit the scheme in all particulars. This is indicated by the parentheses.

Malcolm Smith (1943) suggested happened with other characters. Ovoviviparity has probably been attained by species in different phyletic lines here, as it has in other families of snakes.

However, several recent observations seem to show that the boids are not the compact and easily definable group that one would suppose from the general literature. Hoffstetter (1946: 132) pointed out that the two "boids" of Round Island (off Mauritius), *Casarea* and *Bolyeria*, differ from all other boids, including those of Madagascar, in that

Similarly, the presence of a coronoid bone in the lower jaw is commonly assumed to be a familial characteristic, but actually it is quite variable in its appearance. Strongly represented in *Python*, *Constrictor*, and others, it is considerably reduced in *Loxocemus*, *Charina*, *Bolyeria*, and *Casarea*. It seems to be completely absent in at least some species of *Tropidophis* (observation by Walter Auffenberg and me).

Romer (1956: 572–73), in part following "unpublished work of McDowell," recognized not only the subfamilies Pythoninae and Boinae, but added two more, the Sanziniinae and the Erycinae. The Sanziniinae, containing the genera *Acranthophis, Bolyeria, Casarea,* and *Sanzinia,* appears to rest upon a misinterpretation of the findings of Hoffstetter (1946) and Anthony and Guibé (1951, 1952). The definition given by Romer is, "Similar to Boinae, but hypapophyses on all thoracic vertebrae." As indicated by Hoffstetter, the Round Island genera, *Bolyeria* and *Casarea,* differ from the Madagascaran genera *Acranthophis* and *Sanzinia* in the possession of hypapophyses posteriorly. This is corroborated in part by some middorsal vertebrae of *Sanzinia* at hand, which lack hypapophyses (Fig. 3). In addition the Boinae were defined in part by Romer as having, "internal process of palatine short; prefrontals in contact." These criteria do not hold for either *Casarea* or *Bolyeria* (*vide* Anthony and Guibé, 1952: Figs. 2, 3, 4). contact in Boinae). These may well be valuable characters, and if all are correlated may be good indicators of relationship, but in view of the discrepancies noted above they deserve further checking before they are accepted as valid points of differentiation.

Thus while the Boidae as currently understood is made up of snakes that differ widely in their morphological characteristics, these characters have been reported in too few

Fig. 3. Vertebra of *Sanzinia*; lateral view of middorsal vertebra showing the absence of hypapophyses in this Madagascaran boid. [Drawing by camera lucida from a specimen in the University of Arkansas collection.]

Fig. 4. Representative snake vertebrae; lateral views of middorsal vertebrae in several families showing the appearance of the hypapophyses. a. *Natrix taxispilota* (Colubridae, "Natricinae"), b. *Notechis scutatus* (Elapidae, Elapinae), c. *Laticauda fasciata* (Elapidae, Hydrophiinae), d. *Naja flava* (Elapidae, Elapinae), e. *Agkistrodon piscivorus* (Viperidae, Crotalinae). [Drawings made by camera lucida from specimens in the University of Arkansas collection.]

Thus the Sanziniinae is neither a natural group nor is it properly defined.

The subfamily Erycinae also is probably an artificial group. The characteristic of the anteriorly placed premaxillary appears to be a burrowing adaptation, and is also found in *Bolyeria* (*vide* Anthony and Guibé, 1952 Fig. 4). The characteristic of a purely lateral prefrontal is shared with both *Bolyeria* and *Casarea.*

Three additional characters for differentiating the Boinae from the Pythoninae are given by Romer. These are the internal process of the palatine (long in Pythoninae, short in Boinae), the lacrimal foramen (closed in Pythoninae, open ventrally in Boinae), and the prefrontals (separated in Pythoninae, in representatives to be used as bases for the formation of recognizably phyletic subfamilial groupings.

Definition of the Boidae.—Premaxillary and maxillary bones not in contact; maxillary toothed, premaxillary toothed or not; nasal and prefrontal bones in contact (not "su-.ured"); supratemporal bone elongate and scale-like, not intercalated in braincase; coronoid bone in lower jaw (? except *Tropidophis*); pelvic elements present (? except *Bolyeria* and *Casarea*). Left lung 30 to 80 percent the size of the right (? except *Tropidophis* and *Trachyboa*). Head scutellation of many moderate-sized species made up of large shields, usually with a median rhomb-shaped parietal member bounded diagonally

by paired members, head scutes of large species usually broken into small scales; a brille present; ventrals about three-quarters width of body or larger.

Distribution and content.—These snakes are found throughout the tropics of both hemispheres (including Australia), and extend well into the temperate regions of western North America. About 25 genera are currently recognized with perhaps 100 species.

Family Aniliidae

The aniliids are closely related to the boids and are distinguished from them by only a few burrowing adaptations. The family is commonly recognized to be made up of a single South American genus (*Anilius*) and two genera (*Anomalochilus, Cylindrophis*) in southeastern Asia. Romer (1956: 570–71) has tentatively extended the limits of the Aniliidae to include such diverse animals as *Loxocemus* (usually considered as boid), *Xenopeltis* (usually placed in a distinct family), and the "uropeltines" usually regarded as a distinct family). This arrangement has also been followed by Darlington (1957: 221). The only common characteristics of this expanded family are those directly correlated with burrowing adaptations (consolidation and loss of skull elements, narrowing of gape) and the groups as generally defined appear more meaningful phylogenetically. Grouping *Xenopeltis,* which lacks both a coronoid and pelvic elements, with the "uropeltines" that possess a coronoid but lack pelvic elements, and both of these with snakes that have both a coronoid and pelvic elements and differ in other ways, does not appear warranted at the present state of knowledge.

Definition of the Aniliidae.—A group of burrowing snakes, possibly an artificial assemblage, that shows relationship to the boids in having pelvic elements, the anterior extension of the prefrontal, and a coronoid bone in the lower jaw. Burrowing specializations separating these snakes from the boids, as commonly understood, include reduction and intercalation of the supratemporal bone in the braincase, shortened quadrate, premaxillary and maxillary in contact, reduction of the left lung to less than 15 percent the length of the right (*fide* Brongersma, 1951: Fig. 1), and greatly reduced ventral plates (to about twice the size of the dorsals). *Anilius* retains premaxillary teeth but has lost the brille. All members have full complements of palatopterygoid teeth.

Distribution and content.—These snakes are found in northern South America (*Anilius*) and southeastern Asia (*Anomochilus* and *Cylindrophis*). *Anilius* is monotypic, two species are recognized in *Anomochilus,* and seven in *Cylindrophis.*

Family Xenopeltidae

The position of *Xenopeltis unicolor,* the sole representative of its family, has always seemed anomalous. Combining the primitive features of toothed premaxillary, large left lung, and boid head scutellation with such features of advanced snakes as loss of pelvic elements and coronoid bone, it appears in these ways to provide an adequate link between the two. Burrowing specializations including the reduction and intercalation of the supratemporal, short quadrate, and reduced ventrals, on the other hand, set it off from any main boid-colubrid line of descent (but *vide* Haas, 1955).

It shows no indication of relationship with the aniliids or uropeltids such as that suggested in Romer's (1956: 570) arrangement. The recent demonstration that the "boids" *Bolyeria* and *Casarea* also lack pelvic elements and have reduced coronoids suggests that several phyletic lines have "approached" colubrids in these ways and that such absences may have no phyletic value.

Definition of the Xenopeltidae.—Premaxillary and maxillary toothed and in contact; supratemporal reduced and intercalated in braincase; quadrate short; coronoid absent; ectopterygoid present; pelvic elements absent. Left lung about half as long as right (*fide* Brongersma, 1951: Fig. 1). Head scutellation of boid type (a median rhomboid parietal element); ventrals reduced to about one-half body diameter.

Distribution and content.—The monotypic species lives from southern India (but not Ceylon) to Java, Celebes, and Palawan.

Family Uropeltidae

The uropeltids are small (less than two feet long) burrowing snakes that approach colubrids in the loss of pelvic elements and in other features. Only the retention of a coronoid bone in the lower jaw indicates their association with the more primitive families.

In relation to their burrowing and insectivorous habits, the ventral scutes are reduced to little larger than the dorsals, the

body scales are smooth and polished, and the palatopterygoid teeth are absent. Hoffstetter (1939b: 426) pointed out that at least in three species of *Rhinophis* and in *Uropeltis grandis* the centrum of the atlas is fused to the occipital condyle of the skull. This apparently gives extra strength and leverage in pushing the head through the soil. This character has not been investigated in other species and it is not known whether it might be used as a definitive feature of the family. In this respect, however, the uropeltids appear to be more specialized for burrowing than even the leptotyphlopids.[1]

Romer (1957: 571) included the uropeltids as a subfamily in his expanded family Aniliidae, but they differ as a group from the members of that family as commonly recognized. He also included *Anomochilus* and *Cylindrophis* in this subfamily, but they (and *Anilius*) differ from uropeltids in the possession of pelvic elements, a supratemporal bone, and palatopterygoid teeth.

Definition of the Uropeltidae.—A family of burrowing snakes characterized by the presence of a coronoid bone in the lower jaw, the absence of pelvic elements, and the absence of a supratemporal bone in the skull. Teeth on both maxillary and dentary bones, absent on the palate. The skull is highly consolidated with the maxillary sutured to the premaxillary and prefrontal bones. All but the members of a single genus, *Platyplecturus,* have lost the brille (*fide* Mahendra, 1938: 347); ventrals reduced to size of dorsals, two per body segment.

Distribution and content.—These snakes are restricted to the southern part of the Indian peninsula and Ceylon. Some seven genera and 45 to 50 species are currently recognized. Many of these "species" have been named on the basis of single specimens, however, and many differ from other species only slightly and occupy adjacent but exclusive ranges. It seems likely that the recognition of individual, ontogenetic, and geographic variations in this group might reduce the number of recognized species by more than 50 percent.

Family Leptotyphlopidae

A highly specialized burrowing family which, like the Aniliidae, retains most of the primitive features of the lizard-ancestor, but which has also acquired many burrowing adaptations. These latter place it far from the generalized boid or advanced snake families.

Definition of the Leptotyphlopidae.—Maxillary bone sutured to premaxillary and prefrontal bones. Premaxillary, maxillary, palatine, and pterygoid bones edentulous. Supratemporal ?absent (reported in *Leptotyphlops nigricans* by Brock, 1932, but not confirmed by Tihen, 1945: 209); ectopterygoid usually considered to be absent, but believed to be represented by a partially fused hook-like element on the maxillary (*fide* McDowell and Bogert, 1954: 70). Coronoid bone present, teeth present on dentary. Pelvic elements (three, with ischial symphysis in some species) present. Head scutellation highly specialized, brille absent (Fig. 1); ventrals reduced to size of dorsals, two per body segment.

Distribution and content.—Tropical Africa and southwestern to southcentral Asia, and tropical America, extending northward through much of western United States. A single genus with about 50 species, many of which are based on "unique" types.

Family Typhlopidae

Another highly specialized burrowing family of snakes which has recently (McDowell and Bogert, 1954: 88–89) been suggested to be an independent snake-like derivative from lizards. The members of this family differ from the leptotyphlopids mainly in jaw mechanism.

Definition of the Typhlopidae.—Maxillary bone toothed, transverse to axis of cranium, and movable on palatine or "supraorbital." Premaxillary, palatine, and pterygoid bones edentulous. Supratemporal absent; ectopterygoid present (*fide* Dunn and Tihen, 1944: 290) in some genera, presumed to be fused to palatine in others. Coronoid present, dentary edentulous or with a single tooth, a long retroarticular process. Pelvic elements reported to be absent in some species, three elements with pubic and ischial symphyses reported in others (*fide* Evans, 1955: 393). Head scutellation highly specialized, brille absent (Fig. 1); ventrals reduced to size of dorsals, two per body segment.

Distribution and content.—Tropicopolitan, extending slightly into temperate zones. Two subfamilies (*vide* Tihen, 1945: 210), five genera, perhaps 200 species, most belonging to the genus *Typhlops.* Many of the species are based on "unique" types.

[1] Recent reexamination of this feature by Dr. Ernest E. Williams shows Hoffstetter to be in error in this observation.

Family Colubridae

Many different attempts have been made to break this huge family into recognizably phyletic subdivisions. Tooth characters (presence or absence of grooving), vertebral characters (presence or absence of hypapophyses posteriorly), and various features of the hemipenis have been prominent among those suggested as possible "key" characters to phyletic relationship. The grouping of regional faunas through the use of these characters appears to give results of considerable phyletic meaning (*vide* Dunn, 1928; Bogert, 1940; Smith, 1943). These characters break down when attempts are made to use them on a world-wide basis, however, and any key to the relationships within the Colubridae is yet to be discovered. Only a few of the highly specialized groups are currently recognizable as phyletic units.

Extended discussion of the relative value of the characters utilized in the various systems of classification or of the validity of the various colubrid subfamilies currently recognized is outside the scope of this paper. It may be pointed out, however, that recent work has tended to throw considerable doubt on the validity of some of the smaller subfamilies as well as pointing up the complex nature of the larger ones. In a recent paper Dunn and I (1957) showed that the subfamily Xenoderminae, as recognized by Smith (1943) and Romer (1956), includes at least some genera (*Nothopsis, Xenopholis*) whose relations are with the American "xenodontines" rather than the Asian "xenodermines," if such a group actually exists.

The subfamily Dasypeltinae seems to be even more completely demolished by the observation (Gans and Oshima, 1952: 15) that at least one species of the "colubrine" genus *Elaphe* has evolved the presumably unique feature of that subfamily—the penetration of the esophagus by elongated and specialized vertebral hypapophyses. A reevaluation of this morphological feature as a taxonomic character seems necessitated by this information. It is here suggested that the relationships of *Dasypeltis* lie with the African snakes of Bogert's (1940: 11) Group VII (= aglyphous colubrinae), while the relatives of *Elachistodon* should be looked for among the rear-fanged "colubrine" snakes of southeastern Asia.[2]

A family such as the Colubridae that is recognized mainly on the basis of the absence of certain morphological features found in other families may be polyphyletic, but no evidence of this has yet been presented.

Definition of the Colubridae.—A family of snakes that has lost such primitive features as premaxillary teeth, coronoid bone, pelvic elements, and the left lung, but which has not developed venom fangs on the anterior end of the maxillary bone. The skull is extremely kinetic in most representatives with the premaxillary-nasal region movable on the braincase, the tooth-bearing bones of the upper jaw and palate freely movable, and the elongate supratemporal and quadrate bones movable at all contact points. The prefrontals are without long anterior extensions and are not in contact with the nasals. The brille is present in all species. The ventrals are about equal to the body diameter.

Range and content.—Worldwide except the Arctic and Antarctic, some oceanic islands, Ireland, and southern and western Australia. There are about 300 genera and almost 2500 species variously divided among six to ten poorly defined subfamilies.

Family Elapidae

The elapids differ from the colubrids only by having fangs at the anterior end of the maxillary bone, which is usually considerably reduced in length. Boulenger (1893: 169) recognized these snakes as merely a section, Proteroglypha, of the Colubridae, and it might be pointed out that the other fanged series that he recognized, Opisthoglypha, has since been shown to be polyphyletic. Anthony and Guibé (1951, 1952) suggested a polyphyletic origin of the Elapidae, with the derivation of some of them from boids (if *Bolyeria* and *Casarea* are boids). They pointed to the peculiar double maxillary of the Round Island snakes, and suggested that the short maxillary of the elapids might have been formed by merely the loss of the posterior element and retention of the anterior one with nine or ten teeth. The common possession of hypapophyses throughout the vertebral column was also noted.

The differences between boids and elapids are, nevertheless, much greater than those between colubrids and elapids. Even the bolyerine boids retain such characteristics as the coronoid in the lower jaw and the anterior process of the prefrontal bone, which are lost in both colubrids and elapids. The pattern of head scutes is similar in generalized colubrids and generalized elapids, and

[2] Recent reexamination of *Elaphe carinata* indicates that this decision was based on erroneous morphological information (Dowling, 1959).

quite different in boids (including bolyerines). Johnson (1955: 386) found the dorsal aspect of the vertebrae of elapids and colubrids to be indistinguishable, and both quite distinct from those of boids. No boid, to my knowledge, has even a grooved tooth, much less a caniculate fang. Unfortunately neither Hoffstetter (1946: 132), who first pointed out the hypapophyses in the Round Island snakes, nor Anthony and Guibé (1951, 1952) who further investigated the anatomy of these snakes, has figured the vertebral characters involved. A simple statement that hypapophyses are present carries no greater phyletic meaning than does, for example, a statement that the scales are keeled. However, the hypapophyses of elapids are fairly distinctive and elapid vertebrae are readily separable from those of natricine colubrids, or viperids, or the anterior vertebrae (with hypapophyses) of the boids at hand (Fig. 4). It seems reasonable to believe that precise description of the vertebral characters would further negate the suggested relationship of the bolyerines and the elapids.

However, the elapids and the sea snakes of the commonly recognized family Hydrophiidae are demonstrably closely related and differ only in the aquatic adaptations of the latter. It is here suggested that they be placed in the same family. Both differ from the colubrids only in the possession of anterior maxillary fangs, but they share in addition a considerable number of characteristics. Both groups ordinarily lack a loreal plate, but this may be correlated with the reduced length of the maxillary since other snakes with shortened snouts (e.g., *Storeria*) also tend to lose the loreal. Both have hemipenes with a forked sulcus and vertebrae of the elapid type (Fig. 4). Although the specialized members of each group are quite widely divergent, the only features that will consistently differentiate the two groups appear to be the compressed tail and valvular nostrils [?] of the sea snakes. *Acrochordus*, among colubrids, is a much more specialized member of its family than is any sea snake.

The inclusion of all sea snakes in a single subfamily of the Elapidae results, of course, in the non-recognition of the Laticaudinae of Smith (1926: x). This group contains three small genera, but they are not obviously related. For example, the differences in skull features between *Aipysurus* and *Emydocephalus* (Smith, 1926: Figs. 7, 14) are considerably greater than those between cobras and mambas. Of the various characters mentioned (pp. x–xi) as distinguishing his two subfamilies, none, with the possible exception of the shape of the rostral plate (which is not given in the descriptions of individual species or genera), is definitive. Each of the characters mentioned proves to have several exceptions.

I also fail to find the maxillary of *Dendroaspis* (*vide* Bogert, 1943: Fig. 47) so distinctive as to provide the basis of separate subfamily (Dendroaspinae) proposed by Romer (1956: 585). The differences between it and that of cobras appear negligible when compared with the great differences between the maxillaries of *Naja* (Bogert, 1943: Figs. 69–71) and *Ultrocalamus* (De Rooij, 1917: Fig. 110), which are placed in the same subfamily by Romer.

Definition of the Elapidae.—A family of snakes lacking primitive features of premaxillary teeth, coronoid bone, pelvic elements, and left lung, and possessing venom fangs on the anterior end of the maxillary bone, which is rather elongate and nonrotating. Hypapophyses are found throughout the vertebral column (Fig. 4); the hemipenis has a forked sulcus; the loreal plate is absent except in rare individuals. The prefrontal bones lack an anterior process, but are in contact with the nasals in some forms (e.g., *Pelamis, vide* Smith, 1926: Fig. 33) where the frontals are greatly reduced. The brille is present in all species.

Range and content.—The major distribution is in the Australian, Oriental, and Ethiopian regions, with a single group (but numerous species) in the Neotropical region (*vide* Bogert, 1943: 313–16). A single sea snake (*Pelamis platurus*) has extended its range across the Pacific Ocean to the western coast of the Americas. A few species occur outside the tropics, two in the southern United States.

There are two subfamilies as here recognized, the Elapinae with about 30 genera and perhaps 150 species, and the Hydrophiinae with 15 genera and about 50 species currently recognized. Better geographic data (*vide* Volsøe, 1939: 10) and a polytypic species concept might reduce the number of species in the Hydrophiinae to less than half this number (e.g., *Emydocephalus annulatus* Krefft, 1869, and *E. ijimae* Stejneger, 1898, are allopatric, have overlapping characters, and appear to be subspecifically related at most; the same can be said of *Laticauda semifasciata* Reinwardt, 1837, and *L. schistorhynchus* Günther, 1874).

Family Viperidae

Although Boulenger (1893: 2) suggested that the viperid snakes were derived from opisthoglyph colubrids, this has been questioned by numerous workers (e.g., Bogert, 1943: 315; Johnson, 1956: 64), and most of the recent work indicates that they were derived from elapids (for a recent contrary view see Savage, 1957: 165). The "true vipers" and the "pit vipers" have variously been considered as families (Schmidt, 1950: 81; Johnson, 1956: 56) or as subfamilies (Mahendra, 1938: 354; Bellairs and Underwood, 1951: 198). It is here suggested that they be considered of subfamilial rank.

The determination whether to combine or to split these two groups is not to be based on their distinctness, but rather on whether the aims of classification are best served by splitting this unquestionably natural group into two. Other than the presence of a loreal pit (and correlated excavated maxillary bone) in one group and its absence in the other, the two are essentially identical. The characteristic single fang on a rotating maxillary bone is shared by them and found in no other group. The scutellation, skeletal structure, and general habitus are all extremely alike, and the two groups have similar habits and have invaded the same kinds of habitats (Schmidt, 1950: 83). There seems to be no reason to question that the Crotalinae have evolved from the Viperinae within relatively recent times (*vide* Johnson, 1956: 64).

Definition of the Viperidae.—A family of snakes lacking primitive features of premaxillary teeth, coronoid bone, pelvic elements, and left lung, and possessing a single venom fang (with an alternate) on an extremely short and otherwise toothless rotatable maxillary bone. The ectopterygoid is elongate; long hypapophyses are found throughout the vertebral column; the hemipenis is forked and has a forked sulcus; the head plates are often highly modified but generalized species show the typical colubrid pattern. The prefrontal bones lack an anterior process and are not in contact with the nasals. The brille is present in all species. The ventrals are about equal to the body diameter.

Range and content.—These snakes are found in Eurasia and Africa (Viperinae), and the Americas and eastern Asia (Crotalinae). There are two subfamilies as here recognized, the Viperinae with about ten genera and perhaps 30 species, the Crotalinae with five genera and about 50 species.

Summary and Conclusions

K. P. Schmidt's suggestion that the Sauria and Serpentes be recognized as separate orders of reptiles is opposed on the ground that there is no sharp line of demarcation between the two and that their close relationship should be indicated by retention as suborders in the order Squamata.

The difference between *demonstrably* primitive serpent characteristics and those merely believed (by some) to be primitive is clarified. It is suggested that such features as narrow gape, contact of maxillary and premaxillary, absence of enlarged ventral scutes, and absence of a brille are not necessarily primitive snake features, but may better be considered as burrowing specializations. On the other hand, the presence of pelvic elements, a coronoid in the lower jaw, premaxillary teeth, and a large left lung are undoubtedly characteristics inherited from a lizard ancestor. A combination of such characteristics is found only in the family Boidae.

The repeated suggestions that superfamilies be used in the Serpentes is opposed at the present state of knowledge. Such superfamilial categories have been left undefined by most of their advocates, and the recent definitions by Romer are either not true for some included groups, or are based on characteristics without phyletic value.

Each of the living families of snakes recognized here is discussed and defined. Some of the recent work pertinent to a study of their relationships is mentioned. The subfamilies of the Boidae proposed by Romer are analyzed and rejected, as is his arrangement of the primitive burrowing snakes (Aniliidae, Uropeltidae, Xenopeltidae) in a single family. The complexity of relationships within the Colubridae is noted and the subfamily Dasypeltinae is relegated to synonymy.

It is suggested that the family Hydrophiidae be made a subfamily of the Elapidae, and that the other subfamilies (Laticaudinae and Dendroaspinae) be dropped. The suggestion of Anthony and Guibé that the "boid" snakes *Bolyeria* and *Casarea* are annectent to the elapids is critically examined and rejected. Previous allocation of the pit vipers to the family Viperidae is supported.

Except for the single proposal concerning the sea snakes, therefore the taxonomic conclusions presented here are conservative.

The snakes as a whole deserve a great deal more diversified work than they have received. The lack of knowledge of snake anatomy and of the variation in internal characters are stumbling-blocks to their proper taxonomic arrangement. No segment of the serpents can be considered well-known, but problems of outstanding importance include: 1) the relationships of the Typhlopidae to the Leptotyphlopidae, and both to other snakes, 2) further investigation of the anatomy and relationships of *Bolyeria* and *Casarea* and other poorly known "boids," 3) the interrelationships of the members of the Aniliidae and their relationship to the boids, 4) subspecific relations in the Uropeltidae and the relations of that family, 5) the morphology of the primitive elapids of the Australian region, 6) the proper status of *Xenopeltis*, and of course the main problem, 7) the proper partition of the family Colubridae.

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My interest in the relationships of the Serpentes was initiated during my studies at the Museum of Zoology, University of Michigan. A critical review of the families of snakes was presented in the herpetology seminar there in 1950. I wish to thank Drs. Norman Hartweg and Charles Walker particularly for the stimulation of this interest through their informed discussions, and am indebted to the entire staff of the University Museums for the free spirit of inquiry that pervades that institution.

Discussion of snake relationships with the late Emmett R. Dunn at Haverford College pointed up discrepancies in the literature of serpent anatomy and aided greatly in gaining some better perspective of the Serpentes as a whole.

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Literature Cited

Anthony, Jean and Jean Guibé. 1951. *Casarea*, forme de passage entre les Boides et les Serpentes Proteroglyphes. *Comptes rendus des seances de l'Academie des Sciences Paris, tome 233, pp. 203–04.*

—— and ——. 1952. Les affinities anatomiques de *Bolyeria* et de *Casarea* (Boides). *Mem. l'Inst. Sci. Madagascar, ser. A, tome 7, fasc. 2, pp. 189–201.*

Bellairs, A. d'A., and J. D. Boyd. 1947. The lachrymal apparatus in lizards and snakes. I. The brille, the orbital glands, lachrymal canaliculi and origin of the lachrymal duct. *Proc. Zool. Soc. London, vol. 117, pp. 81–108.*

——, and Garth Underwood. 1951. The origin of snakes. *Biol. Rev. Cambridge Philos. Soc., vol. 26, pp. 193–237.*

Bogert, Charles M. 1940. Herpetological results of the Vernay Angola expedition. Part. I. Snakes, including an arrangement of African Colubridae. *Bull. Amer. Mus. Nat. Hist., vol. 77, pp. 1–107.*

——. 1943. Dentitional phenomena in cobras and other elapids with notes on adaptive modifications of fangs. *Bull. Amer. Mus. Nat. Hist., vol. 81, pp. 285–360.*

Boulenger, George, A. 1893–1896. Catalogue of the Snakes in the British Museum (Natural History). *Vols. I–III. London: Taylor and Francis.*

Brock, G. T. 1931. The skull of *Leptotyphlops* (*Glauconia nigricans*). *Anat. Anz. bd. 73, pp. 199–204.*

Brongersma, L. D. 1951. Some remarks on the pulmonary artery in snakes with two lungs. *Zoologische Verhandelingen, no. 14, pp. 1–36, fig. 1, pls. 1–9.*

Darlington, Philip J., Jr. 1957. Zoogeography: the Geographical Distribution of Animals. *New York: John Wiley and Sons, xi + 675 pp., 80 figs.*

De Rooij, Nelly. 1917. The Reptiles of the Indo-Australian Archipelago. II. Ophidia. *Leiden, E. J. Brill, pp. xiv + 334, 117 figs.*

Dowling, Herndon G. 1959. Egg-eating adaptations in the Chinese ratsnake, *Elaphe carinata* Günther. *Copeia 1959 (1): 68–9.*

Duméril, André M. C., and G. Bibron. 1844. Erpétologie général ou histoire naturelle complete des reptiles. *Paris: Libraria Encyclopedique de Roret. Tome VI.*

Dunn, Emmett R. 1928. A tentative key and arrangement of the American genera of Colubridae. *Bull. Antiv. Inst. Amer., vol. 2, no. 1, art. 33, pp. 18–24.*

——, and Herndon G. Dowling. 1957. The neotropical snake genus *Nothopsis* Cope. *Copeia, 1957, no. 4, pp. 255–61, pl. 1.*

——, and J. A. Tihen. 1944. The skeletal anatomy of *Liotyphlops albirostris*. *Jour. Morph., vol. 74, no. 2, pp. 287–95, 1 plate.*

Evans, Howard E. 1955. The osteology of a worm snake, *Typhlops jamaicensis* (Shaw). *Anat. Rec., vol. 122, no. 3, pp. 381–96, 10 figs., 1 table.*

Gans, Carl, and Masamitsu Oshima. 1952. Adaptations for egg eating in the snake *Elaphe climacophora* (Boie). *Amer. Mus. Novitates, no. 1571, pp. 1–16, figs. 8*

Haas, George. 1930. Über das Kopfskelett und die Kaumuskulatur der Typhlopiden und

Glauconiden. *Zool. Jb. (Abt. Anat.), bd. 52, pp. 1–94.*

———. 1955. The systematic position of *Loxocemus bicolor* Cope (Ophidia). *Amer. Mus. Novitates, no. 1748, pp. 1–8, 2 figs.*

HOFFSTETTER, ROBERT. 1939a. Contribution a l'etude des Elapidae actuels et fossiles et de l'osteologie des ophidiens. *Arch. Mus. Hist. Nat. Lyon, tome 15, mem. 3, pp. 1–78, 13 figs., pls. 1–2.*

———. 1939b. Sur l'articulation occipito-vertebrale des Uropeltidae (Ophidiens fouisseurs). *Bull. Mus. Nat. Hist. Nat. Paris, ser. 2, tome 11, no. 5, pp. 426–33, 2 figs.*

———. 1946. Remarques sur la classification des Ophidiens et particulierement des Boidae des Mascareignes (Bolyerinae subfam. nov.). *Bull. Mus. Nat. Hist. Nat. Paris, ser. 2e, tome 18, no. 1, pp. 132–35.*

JOHNSON, RALPH G. 1955. The adaptive and phylogenetic significance of vertebral form in snakes. *Evolution, vol. 9, no. 4, pp. 267–88, 5 figs., 6 tables.*

———. 1956. The origin and evolution of the venomous snakes. *Evolution, vol. 10, no. 1, pp. 56–65, 1 fig., 1 table.*

MCDOWELL, SAMUEL B., JR., AND CHARLES M. BOGERT. 1954. The systematic position of *Lanthanotus* and the affinities of the anguinomorphan lizards. *Bull. Amer. Mus. Nat. Hist., vol. 105, art. 1, pp. 1–142, 43 figs., pls. 1–16, 3 tables.*

MAHENDRA, BENI CHARAN. 1938. Some remarks on the phylogeny of the Ophidia. *Anat. Anz., bd. 86, nr. 19/21, pp. 347–56, 3 figs., 1 table.*

MARX, HYMEN, AND ROBERT F. INGER. 1955. Notes on snakes of the genus *Calamaria. Fieldiana: Zoology, vol. 37, pp. 167–209, 27 figs., 5 tables.*

MOSAUER, WALTER. 1935. The myology of the trunk region of snakes and its significance for ophidian taxonomy and phylogeny. *Publ. in Zool. Univ. Calif., vol. 1, pp. 81–120.*

ROMER, ALFRED S. 1956. Osteology of the Reptiles. *Chicago: Univ. Chicago Press, pp. xxi + 772, 248 figs.*

SAVAGE, JAY M. 1957. (Review of) Osteology of the reptiles. *Copeia, 1957, no. 2, pp. 162–66.*

SCHMIDT, KARL P. 1950. Modes of evolution discernible in the taxonomy of snakes. *Evolution, vol. 4, no. 1, pp. 79–86, 2 figs., 1 table.*

———. 1953. A check list of North American amphibians and reptiles. 6th ed. *Pub. Amer. Soc. Ich. Herp., Chicago, pp. viii + 280.*

SMITH, HOBART M., AND ROSEMARY WARNER. 1948. Evolution of the ophidian hyobranchium. *Herpetologica, vol. 4, part 6, pp. 189–93, 2 figs.*

SMITH, MALCOLM A. 1926. Monograph of the sea-snakes (Hydrophiidae). *Pub. British Mus. (Nat.Hist.), pp. xvii + 130, 35 figs., pls. 1–2.*

———. 1943. The fauna of British India, Ceylon and Burma, including the whole of the Indo-Chinese subregion. Reptilia and Amphibia. III. Serpentes. *London: Taylor and Francis, pp. xii + 583, 166 figs., 1 map.*

TIHEN, J. A. 1945. Notes on the osteology of typhlopid snakes. *Copeia, 1945, no. 4, pp. 204–10, 1 table.*

UNDERWOOD, GARTH. 1957a. *Lanthanotus* and the anguinomorphan lizards: a critical review. *Copeia, 1957, no. 1, pp. 20–30.*

———. 1957b. On lizards of the family Pygopodidae: a contribution to the morphology and phylogeny of the Squamata. *Jour. Morph., vol. 100, no. 2, pp. 207–68, 11 figs.*

VOLSØE, HELGE. 1939. The sea snakes of the Iranian Gulf and the Gulf of Oman. *In* Danish Scientific Investigations in Iran, Part I. *Copenhagen, Ejnar Munksgaard, pp. 9–45, 4 figs.*

WALLS, GORDON L. 1942. The vertebrate eye and its adaptive radiation. *Cranbrook Inst. Sci. Bull., no. 19, xiv + 785 pp., 1 pl.*

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Thamnophis sirtalis sirtalis (Linnaeus) in Eastern Canada, Redescription of *T. s. pallidula* Allen

SHERMAN BLEAKNEY

THE GARTER snakes of the genus *Thamnophis* are notoriously plastic in meristic and color characters. These variations can be consistent and confined to a specific or limited geographic area as in the case of *T. elegans gigas* and *T. radix brachystoma*. More often many color phases are found within one area as with *T. sirtalis* ssp. in British Columbia (Logier, 1955). Early workers in the group assigned specific and subspecific names to these variations, many of which have subsequently been synonymized. Ruthven (1908), pointed out these discrepancies in his classical treatment of *Thamnophis* but he also admitted (p. 183) that some of the variations of *T. sirtalis sirtalis* did predominate more in one area than another. One of his synonyms, *T. s. pallidula* Allen (1899), was described from New Hampshire but never given recognition because similar individuals could be found in many other populations of garter snakes in eastern North America. However, in eastern Canada, this form occupies an ex-

tensive geographic area (Fig. 1). Because this color form is consistent over such a considerable area, I feel that it deserves resurrection, redescription and full recognition as a valid subspecies.

Pigment patterns and scale counts were analyzed on 376 specimens. The material came from the Nova Scotia Museum of Science, the National Museum of Canada, and the Royal Ontario Museum. In addition, Allen's original Bartlett specimens of *pallidula* (U.S.N.M. 26381-3) were borrowed and examined. Each sex is treated separately in regard to scale counts because of marked sexual dimorphism. In Figure 1, the overall limit of the three subspecies of *sirtalis* mentioned in this paper is indicated by a solid line. The specimens were lumped and treated as regional samples and the limits of these six samples are indicated by blocks of horizontal lines. The bands of dots represent areas of intergradation. The origin of Allen's type specimens is marked by a triangle and the location from which the plesiotype came is shown by a dot. Color descriptions in capitals are from Ridgway 1912.

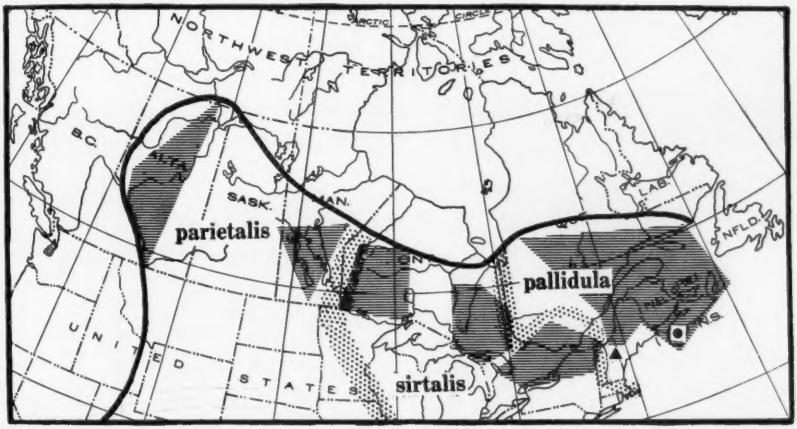

Fig. 1. Ranges of three subspecies of *T. sirtalis* in Canada. Areas of horizontal lines are the six regions which were treated as separate samples. Bands of small dots are areas of intergradation. Triangle depicts the type locality of *pallidula* and the spot marks source of the plesiotype.

Thamnophis sirtalis pallidula Allen, 1899, (redescription)

Type.—Not designated by Allen who gave a composite description. Type locality Intervale, New Hampshire.

Plesiotype.—No. 3095-1 National Museum of Canada. Collected by Sherman Bleakney, 22 July, 1955, at Lake Kejimkujik, Queen's County, Nova Scotia.

Diagnosis.—Overall appearance that of a dark garter snake with conspicuous spots. Only one third of sample has conspicuous dorsal stripe and this is light gray not greenish or yellowish as in *sirtalis*. Light colored postlabial bar absent or only weakly developed, not prominent as in *sirtalis*. Fewer and larger ventral scales and vertebrae than recorded for *sirtalis* populations to the south and west.

Variation.—An average-sized garter snake with prominent spotting. Occurs as three color variations with ground colors of Cinnamon Brown, Yellowish Olive or rarely some shade of Olive Grey. Two-thirds of sample has either no dorsal stripe or has pale incomplete one of Olive Yellow color. Well developed dorsal stripe when present is Pale Gull Grey, not yellowish or greenish as in *sirtalis*. Lateral pale stripes Cinnamon Buff on specimens with brown ground colors. Chamois color on specimens with olive ground color, and greyish on specimen with grey ground color. Lateral pale stripes contrast with ground color above but often merge into darker brown, olive or grey of first row of scales and lateral margins of ventrals. (Lateral pale stripes of *sirtalis* contrast above and below). Ground color broken on each side by two rows of alter-

nating spots composed of groups of 2 to 4 scales of Hazel with black margins. Black skin spots usually rectangular in shape and extending vertically over 5 scale rows in one third of population sample. On brownish specimens the ventral scales anteriorly are Colonial Buff and posteriorly are Olive Buff. On Yellowish Olive specimens the ventrals change from Amber Yellow anteriorly to Tea Green posteriorly. The greyish specimens have Olive Buff to French Grey ventrals. Postlabial bar (which is prominent in *sirtalis*) absent or only weakly developed.

Description of Plesiotype.—Female, total length 628 mm., body length 502 mm. Scutstripe interspersed with black spots along anterior one-third of body only. Posteriorly Olive Ochre confined to dorsal half of first scale row, lower half and margins of ventrals (and subcaudals) being suffused with dull Indian Purple. Below this a row of small black spots beginning at ventral no. 24 and continuing in irregular sequence to anus. Labials, throat and anterior ventrals Amber Yellow, merging with Gnaphalium Green of rest of ventrum. Top and sides of head Yellowish Olive, and suffused with Amber Yellow on the rostral and anterior labial scales. No indication of postlabial bar.

Description from preserved specimen plus color photos of the specimen when alive. The accompanying black and white photos (Fig. 2A) were taken immediately after the specimen was killed and the segment of skin removed included ventrals 34 to 46. Figure 2B is a photo of typical *sirtalis* from Pakenham, Lanark County, Ontario, and the segment of skin covers ventrals 45 to 57.

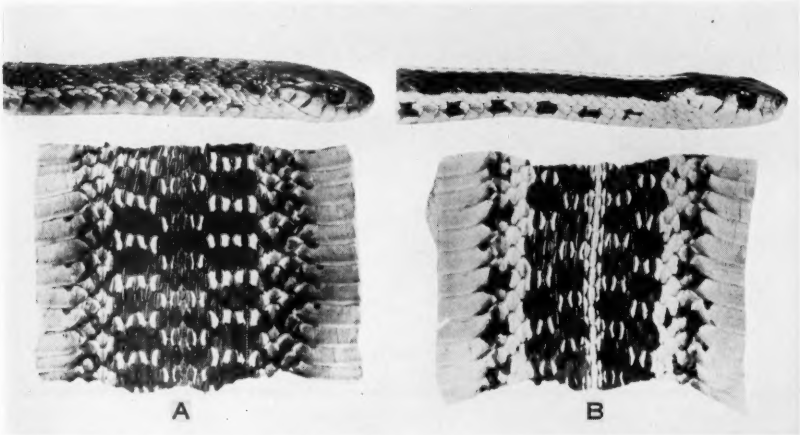

Fig. 2. "A" is the plesiotype of *T. s. pallidula* with a section of stretched skin showing the pigment pattern of the scales and skin. "B" is a typical *T. s. sirtalis* from eastern Ontario.

telation typical for species: 135 ventrals, plus undivided anal scale; 52 pairs of subcaudals plus a terminal spine; 10 lower, 7 upper labials; 1 pre and 3 postoculars; scale rows number 19-19-17.

A dull colored snake with conspicuous dark spots and poorly defined stripes. Middorsal stripe discernible for one third body length as an Olive Yellow streak on the Yellowish Olive ground color. Two rows of alternating spots on each side of Hazel scales with black margins located over the black skin spots. Rectangular black skin spots extend vertically over 5 scale rows, one and one-third scales wide with white interspace two-thirds scale wide. Lateral pale stripes Chamois and on anterior one-third of body merging into Olive Ochre of first scale row and margin of ventral scales. Olive Ochre

Remarks.—I agree with Allen's description except his remark of "dorsal stripe except at its inception, almost obsolete." In the Canadian material at hand, there is some variation, and approximately one-third of specimens have a well defined greyish dorsal stripe, one-third have a short, poorly delimited stripe, and remaining one-third have no stripe at all. None of these varieties seems to predominate in any one area.

Range.—The subspecies ranges throughout

the Atlantic provinces (exclusive of Newfoundland), westward into New Hampshire and thence northwestward to James Bay, and eastward again along the north shore of the Gulf of St. Lawrence. According to Allen (1899, p. 66), it does not extend so far south as Massachusetts. It intergrades with *sirtalis* along its western and southern limits.

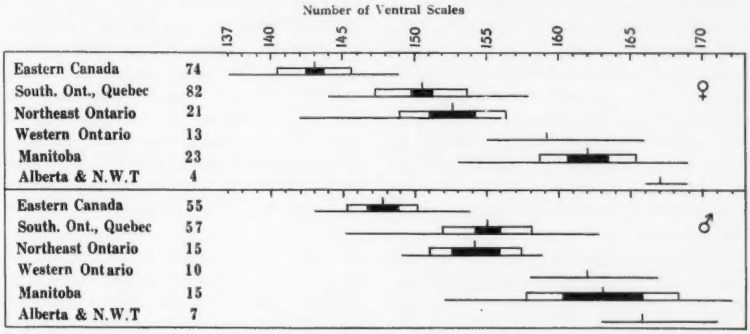

Fig. 3. Ventral scale counts of male and female *T. sirtalis* from Nova Scotia to Alberta. The six samples correspond to the six areas outlined in Fig. 1. Number of specimens measured is indicated after each category. Range, standard deviation, twice the standard error of the mean and the mean are drawn on the graphs.

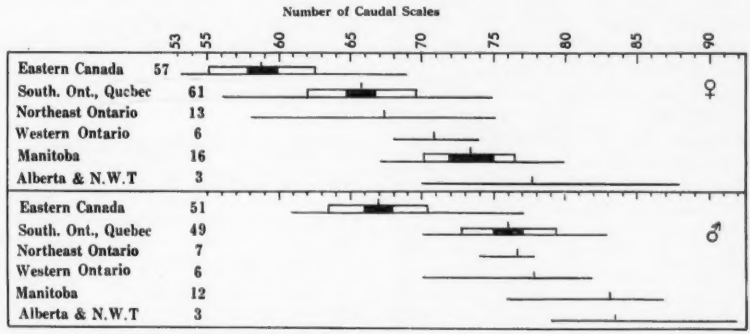

Fig. 4. Caudal scale counts of male and female *T. sirtalis* from Nova Scotia to Alberta.

In southern Quebec and northern New York State *pallidula* makes contact with a population of *sirtalis* which can best be described as of the *obscura* color variety. This unspotted, black and yellow striped garter snake makes up 95 percent to 100 percent of the garter snake population in eastern Ontario, southern Quebec and northern New York. A typical specimen is shown in Figure 2B. Intergrade specimens from southern Quebec have this strongly striped pattern but the ground color is brownish and spotted due to the darker brown and black scales over the skin spots. Examination of Cope's type specimen of *obscura* from Westport, New York, (USNM 974) showed it to belong to this intermediate population.

Most of the Ontario material examined was characterized by prominent stripes, usually bright yellow. However, westward from the rather consistent *obscura* color pattern of extreme eastern Ontario there is much local variation before the prairie *parietalis* form is met with in Manitoba. For instance, around Montreal and in northeastern Ontario (Abitibi and James Bay areas) the light stripes are often orange or red. In the southern peninsula of Ontario the variation in color and pattern is astounding and in some areas 50 percent of the population is melanistic. Logier (*in litt*) says that garter snakes in the Muskoka-Perry Sound district are highly variable colorwise. It would be difficult to group this assemblage under any other subspecific name than *sirtalis*.

To the westward *sirtalis* extends to the Manitoba border where it merges with *T. s. parietalis*. There is a broad band of intergradation here with typical specimens of both color forms and intermediate forms often being found together.

Geographic Gradients.—A study of the scutellation of specimens from all the areas indicated on Figure 1, showed them to be typical of the species *T. sirtalis*. However, as is evident in Figures 3 and 4, there is a definite cline in number of ventral scales, being low in the east and high in the west. This was the only meristic character to show geographic variation. It appears to be solely an east to west gradient, there being no indication of any north to south gradients in any of the samples. This cline is independent of color patterns as is evident in the similarity of the scale counts from the western Ontario and Manitoba samples, the area of transition from the *sirtalis* to the *parietalis* pattern. The greatest gap between any two samples occurs between the Eastern Canada (*pallidula*) and South Ontario-Quebec samples (*sirtalis*), but this gap may be exaggerated since many of the Eastern Canada specimens came from New Brunswick and Nova Scotia, while only a few are from near the intergrade area.

Two geographic gradients which Ruthven first indicated for *T. s. sirtalis* in his 1908 study have been substantiated by this Canadian material. On pages 34, and 182–3 Ruthven says that the percentage of specimens without a dorsal stripe is highest in northeastern United States. This is certainly true in maritime Canada where approximately 66% have reduced or no dorsal stripe. Again on pages 181–2 he observes that the ventral scale counts vary considerably but that the average is rather constant over the species range except for extreme eastern United States, where it tends to be lower. His Figure 81 shows this. Michigan and Ohio (146 specimens) average about 153 ventrals and Massachusetts and Rhode Island (72 specimens) are near 147 ventrals. (Unfortunately, his data are compounded from both sexes and so cannot be directly compared with my material. As my graphs demonstrate, there is sexual dimorphism in both ventral and caudal counts). Figures 3 and 4 illustrate a strong east-west cline from the Atlantic coast to Alberta, with the lowest count in the east as Ruthven predicted. There is a difference in the mean scale counts between the Eastern Canada and the South Ontario-Quebec samples of 7.3 and 7.5 ventrals for males and females, and 9.1 and 6.9 caudals, for males and females. This difference in scale count is absolute, not relative in relation to the lengths of the snakes. By counting scales on four females from Ontario and four females from Nova Scotia with the same body lengths, it was found that the Nova Scotia specimens had 6 to 7 fewer ventrals and 7 to 10 fewer caudals. Because the number of ventrals is directly proportional to the number of vertebrae it follows that *T. s. pallidula* specimens have fewer and larger vertebrae than *T. s. sirtalis* specimens of the same length.

The writer is indebted to E. B. S. Logier for his generous loan of specimens from northern and western areas and helpful criticisms of the original manuscript. A special loan of type and paratype material from the United States National Museum by Dr. Doris Cochran and Dr. R. Kellogg is greatly appreciated.

Literature Cited

Allen, G. M. 1899. Notes on the reptiles and amphibians of Intervale, New Hampshire. *Proc. Boston Soc. Nat. Hist. 29: 63–75.*

Logier, E. B. S., and G. C. Toner. 1955. Check-list of the amphibians and reptiles of Canada and Alaska, *Contrib. Roy. Ont. Mus. Zool. Palaeont. No. 41: 1–88.*

Ridgway, R. 1912. Color Standards and Nomenclature. Washington D. C.

Ruthven, A. G. 1908. Variations and genetic relationships of the garter snakes, *U. S. Nat. Mus. Bull. 61: 1–201.*

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A New Subspecies of *Eumeces multivirgatus* from Mexico

JAMES D. ANDERSON AND DANIEL C. WILHOFT

SKINKS of the *Eumeces multivirgatus* complex have long puzzled systematists. Recent papers by Lowe (1955), Maslin (1957), and especially Mecham (1957), have done much to clarify the relationships between the enigmatic *gaigei* and *taylori* and the widespread strikingly marked *multivirgatus*. Despite the interest in the distribution and systematics of this group, there has been no recent investigation of this species in Mexico. Taylor (1936) figures a *multivirgatus* from Chihuahua, Chihuahua, (USNM 30833). The same specimen is mentioned by Smith (1946) and again by Smith and Taylor (1950) but in the latter publication is recorded as having no specific locality. This specimen of uncertain origin was until now the only known record of *multivirgatus* from Mexico. However, a collection made in the Sierra Madre of western Chihuahua during July, 1957, includes 10 specimens of an apparently new race of *Eumeces multivirgatus*.

Eumeces multivirgatus mexicanus,
subsp. nov.

Fig. 1

Holotype.—Museum of Vertebrate Zoology, University of California, adult male, No. 66061.

Type Locality.—Yaguirachic, 29 degrees 35 minutes N. Lat., 108 degrees 10 minutes W. Long., 130 miles west Chihuahua City, Chihuahua, Mexico: collected by J. D. Anderson on July 2, 1957.

Paratypes.—MVZ Nos. 66056–66060, 66062–66065, collected on July 2–3, 1957.

Diagnosis.—Differing from other subspecies of *Eumeces multivirgatus* in having the lateral surface between the dorsolateral and lateral light lines remaining as a solid dark band, a dorsal dark line lateral to middorsal light line restricted to lateral one-half of first scale row; in retaining a broad, well-defined middorsal light line, a light lateral line on the fourth and fifth scale rows, and a generally darker ground color throughout life making for very contrasting light lines as opposed to contrasting dark lines in the other subspecies, and a bright metallic blue tail in most adults. The following scale characters also distinguish it from most other populations of *multivirgatus*: complete absence of postnasals and a low dorsal scale count (average 54.3, range 53–57).

Description of Holotype.—Snout-vent length 52.1 mm., tail length 45.2 mm., length of hind limb 18.5 mm., fore limb 13.5 mm., head length 9.9 mm., head width 7.5 mm., depth of head 4.9 mm., interorbital distance 4.2 mm., dorsal scale rows 57, scales around the body 24, upper labials 7–7, postmentals 2, nuchals 2–1, postnasals absent, frontonasal undivided, prefrontals not in contact, parietals not in contact behind interparietal, interparietal slightly wedged-shaped with prominent parietal eye. The tail, although tapering to a point and normal in shape and scalation, is so short that it is probably regenerated.

Color.—Color pattern consisting of dorsally five well-defined light lines extending from the snout on to the basal third of the tail; these contrasting with intervening dark ground color. The distal two-thirds of the tail was blue in life, though not the metallic blue of some of the specimens of comparable size. The proximal third of the tail is patterned as the trunk, the dark ground color grading into the blue rather abruptly while the light lines extend farther and blend more gradually into the tail color. Ventrally a rather uniform slate-blue becoming a brighter blue distally on the tail and blending into an off-white on anterior chin region. This ventral color extends over entire lower surface of the limbs, in strong contrast to their uniformly dark dorsal surfaces. The middorsal light line, whitish in life, is one scale row in width and occupies the medial half of each of the first scale rows. This (line or stripe) bifurcates at the posterior tip of the interparietal scale, the resulting lines continue forward diverging slightly along the outer edge of the frontal and fade out just behind the supranasals. The dorsolateral light line originates on the anterior supraoculars and continues posteriorly as a well-defined white line occupying the central portion of the third scale row on each side. The lateral half of the first scale row and medial half of the third scale row are slightly darker than the intervening area and tend to accentuate the light lines. Strong light lines run down the sixth scale rows on the trunk, anteriorly they cross the ear opening and run into the supraorbitals, posteriorly they run

over the hind limbs fading out on the basal third of the tail. A solid, very dark band occupies the region between dorsolateral and lateral light lines for their entire length.

Variation.—The paratypical series consists of seven adults ranging from 45.4 mm. snout-vent to 63.1 mm. snout-vent (mean 56.0 ± 6.21) and two juveniles with snout-vent lengths of 38.1 and 38.9 mm. Mecham (*loc. cit.*) reports no significant geographic variation in size throughout the range of *multivirgatus*, and *mexicanus* apparently falls well within the limits as described for the species. Only five of the nine paratypes have complete tails and these vary from 46.5 percent to 60.7 percent of the total length among adults. The tail of one juvenile is 23.2 percent of its total length. Mecham reports that specimens of *multivirgatus* have relatively longer tails in the southern part of the range. The small series of *mexicanus* does not seem to follow this pattern.

Mecham (*loc. cit.*) found little consistent geographic variation in scale characters in the *multivirgatus* he studied and concluded that local rather than geographic variations are probably most important in this species. Thus the characters to be described below, although consistent in this population and in some respects different from the populations of *multivirgatus*, may be only local variations. However two characters (absence of postnasals and dorsal scale count) show such divergence that future work will probably prove them to be consistent throughout the range of *mexicanus*.

The most striking difference in scale characters is the absence of postnasal scales in *mexicanus*, while less than 10 percent of the specimens studied by Mecham showed this condition. The dorsal scale count averages 54.3 (range 53–57), a considerably lower figure than any reported for other populations. A series from San Miguel Co., New Mexico, had the lowest count of specimens available to Mecham (*loc. cit.*: 116). Scales around the body average 24.4 (range 23–26) with only one specimen having a count of 23. Mecham found 23 scale rows only in specimens from San Miguel County, New Mexico. All our specimens of *mexicanus* have seven upper labials and all have the characteristic two postmentals. Only one specimen has the interparietal enclosed by the parietals. In three, the prefrontals are in contact, being most like specimens from the Guadalupe Mts. of Texas in this respect and least like most others where prefrontal contact is on the order of 70 percent or better. Thus, on the basis of these few specimens, it would seem that in scalation *mexicanus* is most like the southwestern form *E. m. gaigei* (*sensu* Mecham *loc. cit.* 121).

There is little variation in color pattern, even between juveniles (38.1 and 38.9 mm. snout-vent) and breeding adults (62.1 and 63.1 mm. snout-vent). In all, the ground color is very dark, and the mid-dorsal and dorso-

Fig. 1. *Eumeces multivirgatus mexicanus:* upper figure holotype, lower figure lateral view of paratype showing dark lateral band.

lateral light lines are greatly accentuated. In most older specimens the ground color is darker laterally than dorsally, the lateral surface between dorsolateral and lateral light lines thus appearing as a solid dark band. The slightly lighter dorsal ground color tends to strengthen the straight sided dark lines confined to the first scale rows, which in turn outline the uniformly present light mid-dorsal line. The lateral dark band, the well-defined light lines (lateral, dorsolateral, and mid-dorsal), and the restriction of the dark dorsal line to the lateral one-half or less of the first scale row, are the most striking pattern features of this form and sharply distinguish it from all other specimens of *multivirgatus* that we have seen as specimens or figures. As is evident from above description, *mexicanus* adults retain many pattern characteristics which are typical of immature specimens elsewhere, especially *E. m. gaigei* (Mecham: *personal communication*). Whether these pattern characters are to be considered primitive for the species or neotenic is a matter of speculation.

Ecologic Notes.—All 10 specimens were collected near a small, moist meadow at an elevation of 8500 feet. Scattered logs and slabs of bark, the result of recent logging, provided abundant cover. The skinks seemed to prefer logs resting on moist soil rather than piles of limbs or bark. The meadow was bordered on three sides by a uniform forest of Yellow Pine (*Pinus chihuahuana*). Scattered Madrone trees (*Arbutus*) and various oaks (*Quercus*) were present on the slopes, especially in openings and near rock outcrops. A Bracken fern (*Pteris*) covered much of the ground. A small stream meandered through this meadow and drained to the south into a narrow canyon which supported a stand of Douglas Fir (*Pseudotsuga*). Skinks were found only in the immediate vicinity of the meadow.

Capture of the first skinks coincided with the first heavy summer rains (July 1). All were taken between 7:45 and 9:30 a.m. on days following heavy rains. One adult male had a cloacal temperature of 14.6° C. Temperatures of 14.2°, 16.0°, 19.8°, and 20.9° C. were recorded under litter at times of capture. It is probable that the animals are active on the surface only in the early spring and during the summer rainy season. Females were gravid, indicating that the breeding season also coincides with the summer rainfall. Other lizards taken in the same general area, *Sceloporus jarrovi* and *S. grammicus*, also showed signs of breeding.

Eumeces m. mexicanus almost certainly ranges north towards the border where it probably intergrades with the Arizona-New Mexico populations. To the south other species apparently occur in the high pine forests and these may replace *mexicanus* geographically. Zweifel (1954) records *E. brevirostris*, a distinctly different species, from extreme southern Chihuahua. However, the presence of other species may not be limiting since *E. callicephalus* is known from the high Sierra Madre Occidental but is apparently ecologically isolated from the new form. The distribution and ecology of several species of *Eumeces* that occur in northwestern Mexico is a fertile field for future study.

It will be of interest to see if future collecting produces specimens of the *multivirgatus* group in the arid foothills of Chihuahua. Mecham's (1957) work indicates that the variant "*taylori*" and "*gaigei*" pattern types may be selected for in the lower, more arid areas of the southwestern United States, and a parallel situation may exist in Chihuahua.

Acknowledgments

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Literature Cited

Leopold, A. Starker. 1950. Vegetation zones of Mexico. *Ecology, Vol. 31, No. 4: 507–18.*

Lowe, C. H., Jr. 1955. The evolutionary relationships of the narrow-lined skinks of the inland southwest, *Eumeces taylori, E. gaigei,* and *E. multivirgatus. Herpetologica, 11: 233–5.*

Maslin, T. Paul. 1957. Notes on the lizard *Eumeces multivirgatus gaigeae* from Colorado and Utah. *Herpetologica, 13: 87–90.*

Mecham, John S. 1957. The taxonomic status of some southwestern skinks of the *multivirgatus* group. *Copeia, 2: 111–23.*

Smith, H. M. 1946. Handbook of lizards. *Comstock Publ. Co., Ithaca, xxi + 557 pp.*

——— and E. H. Taylor. 1950. An annotated checklist and key to the reptiles of Mexico, exclusive of snakes. *U.S. Nat. Mus. Bull. 199: 1–253.*

TAYLOR, EDWARD H. 1936. A taxonomic study of the cosmopolitan scincoid lizards of the genus *Eumeces*, with an account of distribution and relationships of the species. *Univ. Kansas Sci. Bull., 23: 1–643.*

ZWEIFEL, R. G. 1954. Notes on the distribution of some reptiles in western Mexico. *Herpetologica, Vol. 10(3), pp. 145–9.*

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The Anterior Cranial Elements of the Salamanders *Pseudotriton* and *Gyrinophilus*

ARNOLD B. GROBMAN

THE genus *Gyrinophilus* was established by Cope in 1869 (p. 108) and distinguished from *Pseudotriton* (*Spelerpes*) through the possession of fused premaxillae in the former. Two other osteological differences between the genera were recognized by Cope. The nasal bones were described as well separated from each other in *Gyrinophilus,* but in contact dorsal to the nasal processes of the premaxillae in *Pseudotriton* (*Spelerpes*). It was also stated that in *Gyrinophilus* a prootic-squamosal crest is present which is lacking in *Pseudotriton* (*Spelerpes*). Cope's "Batrachia" (1889:154) contains essentially the same account as is found in the original description.

Dunn (1926) agreed with Cope with regard to the first two characters, did not concern himself with the third, and suggested a fourth osteological character. In his generic diagnoses he described *Gyrinophilus* (p. 259) with "prefrontals present, not bordering nares" and *Pseudotriton* (p. 272) with "prefrontals present, bordering nares." (An apparent contradiction, probably an inadvertent error, appears on page 40. "The prefrontal . . . extends from orbit to nares. This occurs in . . . *Gyrinophilus* and *Pseudotriton.*")

The conditions among the anterior cranial elements of these two genera that have been considered as diagnostic are tabulated in Table I.

The present paper presents a further consideration of these elements in 34 skeletal preparations. The material used includes specimens cleared and stained by the alizarin method (Williams, 1941) by Miss Barbara H. Leonard (*P. r. ruber:* Columbia, S. C., and no locality, and 18 *G. p. porphyriticus*: Allegany State Park, New York); dry skeletons from the collection of Dr. Joe A. Tihen (Nos. 719, 1043, and 1046–1055, *G. p. porphyriticus,* Allegany State Park, New York); and dry skeletons from the University of Michigan Museum of Zoology collections (No. S-686, *P. r. ruber,* and S-689, *P. m. montanus*). Besides the persons instrumental in the preparation and loan of this material, Drs. W. A. Auffenberg, S. C. Bishop, E. R. Dunn, W. J. Riemer, H. M. Smith, and J. A. Tihen are deserving of thanks for the helpful advice they have offered during the preparation of this report. The essential findings are shown diagramatically in Figure 1.

PREMAXILLAE

Two parts of the premaxilla of particular interest in this study are the anterior dentigerous ramus and the posteriorly projecting nasal process. The anterior rami of the premaxillae are fused in larval, recently metamorphosed, and old adult specimens of *Pseudotriton.* In larval *Gyrinophilus* the anterior rami are often fused (6 out of 11 specimens) but in newly transformed and in old adult individuals a suture is usually present (15 out of 16 specimens) between them (Grobman, 1943). Apparently this character is of some diagnostic value only when used with transformed individuals. The suggestion may be offered that the common ancestral stock of *Gyrinophilus* and *Pseudotriton* had the anterior rami fused, at least when in the larval stage. The anterior rami are also fused in *Eurycea.*

The nasal processes of the premaxillae are fused in recently metamorphosed and old adult *Pseudotriton.* In one larva, although they were well fused, the nasal processes had small horns directed postero-laterad from the main mass suggesting that the nasal processes, originally separate, had become fused but that this fusion had been so recent that

it had not yet progressed far enough to obliterate the evidence of the existence of previously paired separate elements. In old adult *Gyrinophilus* the processes are separate; this is also the condition prevailing in four out of five recently transformed individuals. In the fifth the nasal processes were fused as in *Pseudotriton*. All larvae of *Gyrinophilus* that were seen had the nasal processes separate. Wilder (1924) found that approximately five percent of the *Eurycea* she examined had the nasal processes fused. Apparently *Eurycea* illustrates a morphological stage intermediate between *Gyrinophilus* and *Pseudotriton*.

In all three genera the anterior rami are fused in the larvae. This may be considered primitive in the Salamandroidea although it is undoubtedly a specialized situation in comparison with the conditions prevailing in the hynobiids and remote ancestral stocks. In *Eurycea* and *Pseudotriton* the adults have retained the fused rami while adult *Gyrinophilus* have changed from the fused condition. In larval *Eurycea* and *Gyrinophilus* the nasal processes are separate and in larval *Pseudotriton* they are, apparently, recently fused. They remain fused in the adults of *Pseudotriton* and, except for a few instances, remain separate in *Eurycea* and *Gyrinophilus*. Thus in the adult condition in *Pseudotriton* the anterior rami and the nasal processes are fused; in *Eurycea* the anterior rami are fused but the nasal processes separate; and in *Gyrinophilus* both the anterior rami and the nasal processes are separate.

The premaxillae of *Gyrinophilus* and *Pseudotriton* can be most easily derived from a premaxilla which has its dentigerous anterior ramus fused with its fellow and which has its posterior nasal process separate from its mate. The character of the premaxillae cannot be used to consistently distinguish the two genera (as intended by Cope and Dunn) unless restricted to large adults.

Nasals

In recently transformed *Pseudotriton* the nasals are in broad contact along the midline dorsal to the fused nasal processes of the premaxillae. In old adult examples the nasals are separated from each other by the fused nasal processes of the premaxillae but at a point immediately posterior to the premaxillary fontanelle this separation is very slight.

In young metamorphosed *Gyrinophilus* the nasals are separated from each other by the nasal processes of the premaxillae but there is a medial projection from each nasal, just posterior to the premaxillary fontanelle, so that the nasal is separated from its fellow by a distance less than the width of a nasal process of the premaxilla. This condition is reminiscent of the condition in old *Pseudotriton*. In old adult *Gyrinophilus* the nasals are well separated by the nasal processes of the premaxillae.

This character cannot be used in distinguishing between the two genera because it will not correctly identify old adult *Pseudotriton*.

The nasals of adult *Gyrinophilus* and *Pseudotriton* can best be derived from nasals with a broad contact in the midline. This

Table I

Diagnostic Conditions of the Anterior Cranial Elements

Gyrinophilus	*Pseudotriton*
Premaxillae separate	Premaxillae fused
Nasals separated by nasal processes of premaxillae	Nasals in contact dorsal to nasal processes of premaxillae
Prefrontals not bordering nares	Prefrontals bordering nares
Prootic-squamosal crest present	Prootic-squamosal crest absent

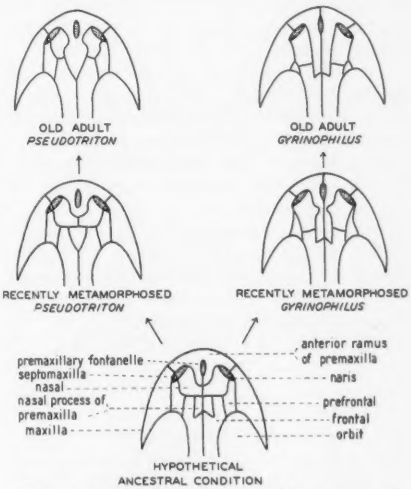

Fig. 1. Development of cranial elements in *Pseudotriton* and *Gyrinophilus*.

is not only the presumed primitive plan for these genera but is the basic arrangement of the nasals in the crossopterygians and embolomerous amphibians. The posterior projection of the premaxillae to form the nasal processes is probably a secondary modification that has occurred early in pre-Salamandroidea history and has influenced the arrangement of the nasals.

It is, of course, possible that because of the paucity of material presently available to me (especially with regard to *Pseudotriton*), the present ontogenetic interpretation may be wrong and the observed differences may actually be a reflection of individual variation in the nasals.

Prefrontals

The term, prefrontal, for the element under consideration, is used reservedly for it is not clear to the writer that this bone is homologous with the prefrontal of other vertebrates nor is the relationship of this element with the lacrymal of related forms clearly understood by me (*vide* Noble, 1921).

In both recently metamorphosed and old adult *Pseudotriton* the prefrontals extend from the orbits to the nares. In recently transformed *Gyrinophilus* the prefrontals extend anteriorly from the orbits varying distances; in some instances they reach the nares. The ontogenetic change in the extent of this element is quite striking for in none of the larger specimens do the prefrontals reach the nares; in most of the old adults these elements are confined to the anteromedial borders of the orbits.

This character is not completely diagnostic for the genera involved for it does not hold in small specimens of transformed *Gyrinophilus*. The primitive prefrontals from which those of *Gyrinophilus* and *Pseudotriton* were derived probably extended from the orbits to the nares.

Other Elements

A septo-maxilla is found in both *Gyrinophilus* and *Pseudotriton*.

The prootic-squamosal crests mentioned by Cope are well developed in adult *Gyrinophilus* and *Pseudotriton* but barely distinguishable in recently metamorphosed individuals. They, also, would not appear to be diagnostic.

Discussion

Dunn considered *Gyrinophilus* and *Pseudotriton* to be closely related with *Gyrinophilus* being the more primitive. This was based largely on the consideration of the fused condition of the premaxillae in *Pseudotriton* for Dunn considered the unfused condition as primitive. Disregarding the premaxillae for the time being, it may be argued that *Pseudotriton* illustrates an earlier stage of evolution than does *Gyrinophilus*. The earlier ontogenetic loss of the meeting of the nasals in the midline and the early retreat of the prefrontals in *Gyrinophilus* suggest that *Gyrinophilus* is specialized beyond the condition found in *Pseudotriton*. A comparison of the diagrams in Figure 1 indicates that young metamorphosed *Gyrinophilus* represent about the same stage of morphological development as is illustrated by old adult *Pseudotriton*.

Returning now to the question of the premaxillae, it has been pointed out above that in the larvae of these forms the anterior rami are usually fused; that this condition has been maintained in *Pseudotriton* and has been modified by the separation of these elements in *Gyrinophilus*. This suggests that fused anterior rami may be regarded as the ancestral condition for these genera. Thus, it may be reasonable to consider fused anterior rami as less specialized than unfused rami, at least in these and related genera. The condition in *Gyrinophilus*, then, represents an advance not found in *Pseudotriton* and should therefore be considered as more specialized. The unusual feature of fused elements developing a suture between themselves ontogenetically is discussed in an earlier paper (Grobman, 1943).

It is consistent with these ideas to entertain the proposition that the *Gyrinophilus* ancestry passed through an early plethodontid stream stage that was followed by a semiterrestrial way of life (as in present *Pseudotriton*) which, in turn, was followed by a return to streams and springs by modern *Gyrinophilus*.

In the lines of ontogenetic change in both genera, trends can be discerned that may be considered adaptive. In *Pseudotriton* the fusion of the nasal processes of the premaxillae and the retreat of the nasals from the midline may be considered an indication of the strengthening of the premaxilla, a tooth-bearing bone. In *Gyrinophilus* the retreat of the nasals from the midline in favor of the extension of the nasal processes of the premaxillae and the posterior retreat of the prefrontals permitting the extension of the maxillae mediodorsad may also be

interpreted as a strengthening of those tooth-bearing elements.

The ontogenetic aspects of the present investigation suggest that the characters utilized by Cope and Dunn as diagnostic do not reflect as great a morphological difference between *Gyrinophilus* and *Pseudotriton* as has heretofore been indicated in the literature. Until future studies demonstrate a greater degree of morphological divergence than is now recognized, it would seem that the relationship between the taxa involved would best be expressed with the single name, *Pseudotriton*. For those who wish to continue the use of *Gyrinophilus*, it is recommended that it be employed as a subgeneric name.

Literature Cited

Cope, E. D. 1869. A review of the species of the Plethodontidae and Desmognathidae. *Proc. Acad. Nat. Sci. Phila., 21: 93–118.*

———. 1889. The Batrachia of North America. *Bull. U. S. Nat. Mus., 34. 525 pp.*

Dunn, E. R. 1926. The salamanders of the family Plethodontidae. *Smith College, Northampton, Mass., xi + 441 pp.*

Grobman, A. B. 1943. The appearance during ontogeny of a suture between previously fused dermal bones. *Anat. Rec. 87: 211–214.*

Noble, G. K. 1921. The anterior cranial elements of *Oedipus* and certain other salamanders. *Bull. Amer. Mus. Nat. Hist., 44: 1–6.*

Wilder, I. W. 1924. Variations in the premaxillae of *Eurycea bislineata. Amer. Nat. 58: 538–43.*

Williams, T. W., Jr. 1941. Alizarin red S and toluidine blue for differentiating adult or embryonic bone and cartilage. *Stain Technology, 16: 23–25.*

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Variation in Skeletal Proportions of *Rana p. pretiosa* in Yellowstone Park, Wyoming

Frederick B. Turner

As a background for further analysis of intra- and interspecific relationships of *Rana p. pretiosa* a study of variation in skeletal dimensions associated with differences in age, sex and geographic locality was carried out in Yellowstone Park, Wyoming. Skeletons prepared from 138 frogs collected from four populations in the vicinity of Fishing Bridge during the summers of 1953, 1954, and 1955, were available for study. These skeletons were prepared from dried carcasses from which the skin, eyes, tongue and viscera had been removed prior to drying.

Six measurements to the nearest 0.1 mm. were made using dial calipers: snout-urostyle length—tip of snout to tip of urostyle; head length—tip of snout to notch at apex of foramen magnum; head width—width of skull at level of junction of maxilla, pterygoid and quadratojugal; femur length—proximal tip of disarticulated femur to distal tip; tibia length—proximal tip of tibia to distal tip; tarsus length—proximal tip of tarsus to distal tip. Bones with obvious abnormalities (e.g. healed fractures, excessive calcification at tips) were not measured. From the measurements these ratios were computed: head length/snout-urostyle length; head width/snout-urostyle length; head width/head length; femur length/snout-urostyle length; tibia length/snout-urostyle length; femur length/tibia length; tarsus length/femur length; and sum of femur, tibia, and tarsus length/snout-urostyle length. These ratios were calculated to the nearest 0.1 percent and serve as expressions of growth of the head and hind limbs in relation to the snout-urostyle length. For the purpose of comparison the measurements and ratios selected for analysis have been based almost wholly on the work of Dunlap (1955) with Oregon ranids. The means of two samples were considered to differ significantly when there was no overlap of twice the standard error of the means.

Growth of the Head

Head width/snout-urostyle length.—Four samples (16 males 31.0 to 50.9 mm. in snout-urostyle length, 16 males 51.0 to 70.9 mm., 20 females 31.0 to 50.9 mm., and 20 females

51.0 to 70.9 mm.) were prepared and analyzed for variation due to sex or age differences. No such differences were revealed. In 100 frogs randomly assorted with respect to sex and age the head width ranged from 23.6 percent to 33.8 percent of the snout-urostyle length (σ = 1.9 percent) with a mean of 27.6 percent.

Head length/snout-urostyle length.—Ten samples representing four size-groups of males and six size-groups of females were analyzed and the results are represented in Figure 1. There is evident decrease of the head length/snout-urostyle ratio with greater age and in general there seems to be no difference between the sexes.

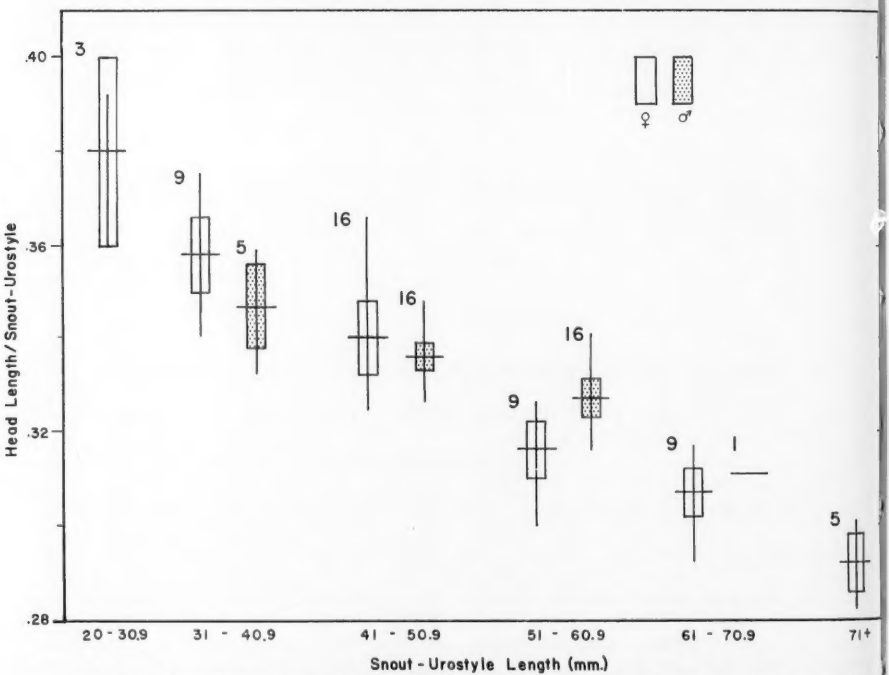


Fig. 1. Head length/snout-urostyle proportions in 89 *Rana p. pretiosa* from Yellowstone National Park, Wyoming. Vertical lines represent ranges, transverse lines means, and rectangles twice the standard errors of the means. Figures indicate sample size.

Head width/head length.—In view of the foregoing facts one would expect the head width/head length ratio to increase with age and there should be no significant difference between the sexes. Thirty-eight males and 38 females (31.0 to 60.9 mm. in snout-urostyle length) were compared and no significant difference was revealed. The sexes were lumped for the purpose of investigating age differences and the result of this procedure is represented in Figure 2.

Growth of the Hind Limb

Five ratios associated with the growth of the hind limb were analyzed. Four of these ratios showed significant differences, apparently related to age and/or sex (Fig. 3). No such differences were found in the ratio of tarsal length to femoral length. In 100 frogs randomly assorted with respect to age and sex the tarsus ranged from 45.3 percent to 55.8 percent of the length of the femur (σ = 1.74 percent) with a mean of 50.6 percent.

Analysis of Four Populations

Preliminary analyses were made with equal numbers of frogs from each of the four populations involved. After the pattern of variation, if any, associated with sex and age differences had been determined, appropriate samples were made for the purpose of ana-

lyzing possible population differences. Evidently, in the case of the head width/snout-urostyle and tarsus/femur ratios the samples could be random with respect to age and sex but in investigating the other ratios some selectivity was necessary. All proportions except the head width/head length ratio were analyzed and the results are summarized in Table I.

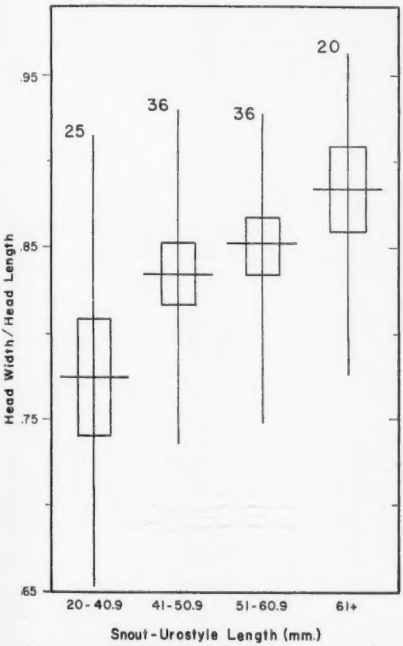


Fig. 2. Head width/head length proportions in 117 *Rana p. pretiosa* from Yellowstone National Park, Wyoming. Explanation of diagrams as in Fig. 1.

Discussion

Relative growth of the head.—Apparently increase in head width is directly proportional to increase in body length in both sexes. Head width is on the average about 28 percent of the snout-urostyle length. Dunlap (1955) reported a value of 36.19 percent for 20 male *Rana pretiosa* and 35.38 percent for 20 females but these values are not comparable to my value because of differences in the method of determining head width. Dunlap found no significant sex differences.

Head length increases allometrically with respect to snout-urostyle length so that the head makes up less of the total body length as the frog becomes larger. Within the snout-urostyle size limits where comparison of the sexes was possible (30 to 70 mm.) there is

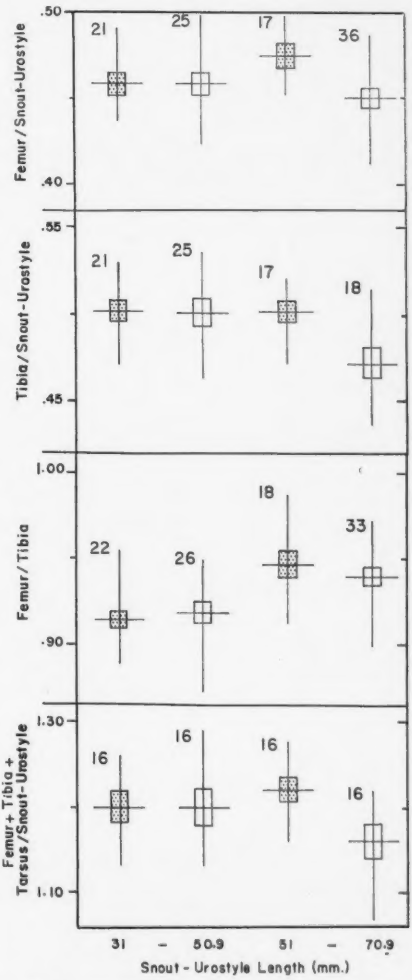


Fig. 3. Proportions involving the hind limb of *Rana p. pretiosa* from Yellowstone National Park, Wyoming. Explanation of diagrams as in Fig. 1.

no evidence of difference between the sexes except in males and females of the 51.0 to 60.9 mm. size class. This difference may be associated with the fact that the mean size of the females of this size group is about 4 mm. greater than that of the males.

Dunlap (1955) reported that in Oregon

Rana pretiosa the females have relatively shorter heads. In 20 females the head length averaged 29.32 percent of the snout-anus length and 20 males averaged 30.83 percent. This difference was significant (alpha = 0.05). I do not conclude that *Rana pretiosa* is sexually dimorphic with respect to relative head length in Oregon but not in Wyoming and suggest that Dunlap's figures actually represent a difference due to age or size and not sex.

The possible influence of age differences was dismissed by Dunlap who assumed that in "adult" animals: "various body structures grow in direct proportion to each other." Dunlap implied that this conclusion is supported by Moore's (1944) work with *Rana pipiens* but Moore's findings (particularly regarding the relationship of head length to body length) strongly indicated the necessity for investigating possible age differences. Moore states: "The body length/head length ratio increases noticeably with an increase in size," and hence the reciprocal ratio (used by Dunlap and myself) would be expected to decrease. From an examination of Figure 1 it may be seen that a difference of 10 mm. in the average size of two samples could account for a difference of the magnitude reported by Dunlap. Since Dunlap stated that his samples were made up of "adults" one visualizes random assortments of 20 adult males and 20 adult females with a range in size of perhaps 30 mm. or more. The average size of adult male and female *Rana p. pretiosa* in Yellowstone Park differs by about 10 mm., the females being larger, and size dimorphism is characteristic of the species over its entire range. Hence in random samples females will be larger than males. Even an average difference of only 5 mm. in size would invalidate assertions that an observed difference in the head length/snout-anus length was due to sex differences.

Because Dunlap measured the head width at the level of the tympanum he considered the head to be wider than long and conse-

TABLE I

RELATIVE SKELETAL DIMENSIONS IN FOUR POPULATIONS OF *Rana p. pretiosa* IN YELLOWSTONE NATIONAL PARK, WYOMING

Mean includes twice the standard error

Ratio		Population			
		Fishing Bridge	Natural Bridge	Lakes	Dragon's Mouth
head length/snout-urostyle	N	13	13	13	13
	Mean	.33 ± .009	.33 ± .010	.33 ± .009	.33 ± .009
	Range	.30 – .36	.30 – .36	.31 – .37	.30 – .35
head width/snout-urostyle	N	16	16	16	16
	Mean	.28 ± .008	.28 ± .009	.28 ± .009	.28 ± .011
	Range	.25 – .31	.25 – .31	.25 – .32	.24 – .31
tarsus/femur	N	16	16	16	16
	Mean	.50 ± .008	.51 ± .005	.50 ± .009	.51 ± .007
	Range	.46 – .53	.50 – .53	.48 – .54	.48 – .53
femur/snout-urostyle	N	13	13	13	13
	Mean	.45 ± .008	.45 ± .011	.46 ± .007	.46 ± .009
	Range	.43 – .48	.41 – .50	.45 – .49	.42 – .49
tibia/snout-urostyle	N	13	13	13	13
	Mean	.48 ± .012	.48 ± .014	.50 ± .008	.50 ± .011
	Range	.44 – .54	.44 – .54	.48 – .53	.44 – .53
femur/tibia	N	16	16	16	16
	Mean	.93 ± .012	.94 ± .009	.93 ± .009	.93 ± .007
	Range	.90 – .99	.90 – .96	.93 – .96	.91 – .95
femur + tibia + tarsus/snout-urostyle	N	25		25	
	Mean	1.17 ± .016		1.22 ± .012	
	Range	1.07 – 1.29		1.14 – 1.27	

quently used the ratio of head length/head width. The fact that reciprocal ratios are involved in the following comparison is of no consequence since both are expressions of head width relative to head length. I found that the head becomes wider with respect to its length with increase in age, an obvious corollary to the relative growth of these dimensions with respect to total body length. Furthermore there is no difference between the sexes. Dunlap found that males have longer heads with respect to width than females, a conclusion consistent with his other data. Here again I believe this is a reflection of non-homogeneity of size in the samples compared.

Relative growth of the hind limb.—The femur and tibia in male and female frogs between 31.0 and 50.9 mm. in snout-urostyle length are of equal length relative to total body length. However, as may be observed in Figure 3, in older frogs (51 mm. or more) the femur becomes relatively longer in males and the tibia shorter in females. These facts may be explained by assuming that the femur in males continues to grow at a constant rate while the body length and tibia increase more slowly with age. In females the femur increases at the same rate as the body length (i.e., both grow more slowly with increased age) but the growth of the tibia is (in females) *even more* retarded so that this bone makes up less of the hind leg in large females. Consequently in males the femur/tibia ratio is significantly higher in larger frogs because of a constant rate of increase in the femur while the tibia grows more slowly, but in females the femur/tibia ratio is higher in larger frogs because, although the femoral growth rate is retarded with age, the growth of the tibia is even more decelerated.

As Dunlap's work was with adult frogs one would expect his ratios to indicate significant differences between the sexes in the femur/snout-anus and the tibia/snout-anus ratios. He found the tibia to be significantly shorter in females but concluded that the femur/snout-anus ratios (males: 48.90 percent, females 47.89 percent) were not significantly different. Nor did Dunlap find significant differences between the sexes in the femur/tibia and tarsus/femur ratios. In the case of the former ratio there is an inconsistency for if the femur/snout-anus ratio is, as Dunlap concluded, equal in males and females and the tibia/snout-anus ratio significantly less in females, then the femur/tibia ratio would be significantly greater in females than in males. The actual values obtained by Dunlap were 98.66 percent for females and 96.06 percent for males but, as has been stated above, these were not considered significantly different.

March (1937), working with measurements of 1522 *Rana temporaria* involving body lengths and total hind leg length (i.e., vent to tip of longest toe), found that growth rate of the hind leg is essentially constant and equal in both sexes until after "puberty," following which the "females are of stouter build than the males, being relatively shorter in the leg and longer in the body, the disparity increasing with the size of the animals." *Rana pretiosa* in Yellowstone attains "puberty" at a size of roughly 50 mm. and hence March's findings are paralleled by my own. As an index of total leg length the sum of the lengths of the femur, tibia, and tarsus has been employed, and a ratio involving this sum and the snout-urostyle length was computed for 64 frogs. The averages of the two sexes among the smaller frogs are identical but adult males and females differ markedly (Fig. 3).

In general, the head of both male and female *Rana pretiosa* increases in width at a rate directly proportional to the rate of increase in body length. The head increases in length at a decreasing rate, making up about 38 percent of the total body length of very young frogs (e.g. 1-year old) but only about 29 percent of this dimension in large adults. In young males and females both the femur and tibia grow at equal rates and maintain a constant relationship to body size. However, in adult males the femur grows relatively faster than in females. And in adult females the tibia does not maintain its earlier rate of increase and consequently represents a smaller portion of the hind leg.

Analysis of four populations.—The only ratios which suggest population differences involve the lengths of the femur and tibia (and their combined length) with respect to snout-urostyle length. A close similarity exists between the Lakes and Dragon's Mouth populations and the Fishing Bridge and Natural Bridge populations. The large variances associated with the samples (a consequence of use of large and small frogs in each sample) obscure a small but real difference in relative length of hind leg. For if the proportion femur + tibia + tarsus/snout-urostyle is employed a highly significant difference between the Dragon's Mouth-Lakes populations and the Fishing Bridge-

Natural Bridge populations is shown. In making this comparison each pair of populations was treated as a unit and the samples balanced with respect to size and sex (i.e. each of the two samples of 25 was made up of five adult males, six adult females, seven subadult males and seven subadult females).

Jameson (1955) found significant differences in skeletal morphology between certain populations of *Syrrhophus marnocki* within a circle of ten-mile radius near Austin, Texas, and east-west clines in relative length of foot, width of head, and length of shank were demonstrated by a comparison of populations from more widely separated parts of Texas. Flury (1951) found significant morphological differences in populations of *Hyla versicolor* from eastern Texas and central Texas. Moore (1944) showed that though individual populations of *Rana pipiens* are fairly homogeneous the species as a whole exhibited significant geographic variation (not necessarily clinal)—in some instances within an area no larger than New England. The significance of these findings lies in the fact that though morphological differences between local or regional populations of frogs may be subtle and not susceptible to ready detection such differences may exist in populations less than ten miles apart. This again emphasizes the danger in making a survey of variation in which no consideration is given to the possibility of variation introduced by minor geographic differences. Such differences may account for variation of demonstrable significance and be of magnitude comparable to that of differences which have been presumed to have taxonomic significance.

Acknowledgments

I wish to acknowledge the role of members of the United States National Park Service in Yellowstone Park, Wyoming, without whose cooperation this study could not have been carried out. Collection of materials was in accordance with the provisions of a Class B permit. Appreciation is also expressed for use of facilities of the Museum of Vertebrate Zoology, and the Department of Zoology, University of California. Finally it is a pleasure to acknowledge the assistance and direction of Dr. Robert C. Stebbins in the preparation of this manuscript.

Literature Cited

Dunlap, Donald G. 1955. Inter- and intraspecific variation in Oregon frogs of the genus *Rana*. *Amer. Midl. Nat. 54: 314–31.*

Flury, A. G. 1951. Variations in some local populations of *Hyla versicolor* in central Texas. Thesis. *The Univ. of Texas, Austin.* (not seen).

Jameson, David L. 1955. The population dynamics of the cliff frog, *Syrrhophus marnocki*. *Amer. Midl. Nat. 54: 342–81.*

March, F. 1937. Relative growth in Amphibia. *Proc. Zool. Soc. London: 415–69.*

Moore, John A. 1944. Geographic variation in *Rana pipiens* Schreber of eastern North America. *Bull. Amer. Mus. Nat. Hist. 82: 345–69.*

Museum of Vertebrate Zoology, University of California, and Department of Biology, Wayne State University, Detroit, Michigan.

Herpetological Notes

EGG-EATING ADAPTATIONS IN THE CHINESE RATSNAKE, *ELAPHE CARINATA* GÜNTHER.—It is well known that ratsnakes of many species will eat birds' eggs, and Gans and Oshima (1952, Amer. Mus. Novitates, no. 1571) have shown that at least one Oriental species, *Elaphe climacophora* Boie, is specialized for this habit. As an addendum in that paper (p. 15), it was stated that, "preliminary investigations of the senior author show that. . . . In *E. carinata* modification of the hypapophyses has progressed to the point of penetration of the esophagus." This is a surprising statement and would suggest that this ratsnake has attained the level of specialization shown by *Dasypeltis scaber*, which does have the naked points of the hypapophyses of some anterior vertebrae extending through the dorsal wall of the esophagus (*vide* Gans, 1952, Zoologica, Vol. 37, pt. 4, art. 18). This in turn strongly suggests that the subfamily Dasypeltinae (including *Elachistodon*), where this is used as the main definitive feature, is a polyphyletic group and not worthy of taxonomic recognition. Chernov (1957, Zoologicheskii Zhurnal, vol. 36, pp. 260–64), pointing to the specialized anterior vertebrae of some other species of *Elaphe*, has come to this conclusion.

Recent visits to institutions that have speci-

mens of *Elaphe carinata* have allowed me to check Gans' observation. An adult specimen in the herpetological collection of the University of Michigan Museum of Zoology (UMMZ 71242) was examined by slitting the ventral body wall and ventral wall of the esophagus from a point immediately behind the head to a point about one-third down the body. Beginning at the level of the tenth ventral scute, a series of 22 sharply-defined knobs protruded into the lumen of the esophagus from the dorsal side. It was determined by touch that these, indeed, were the tips of elongated vertebral hypapophyses projecting downward in this fashion. However, no slits were found in the wall of the esophagus that might allow the actual penetration of that structure by the bony tips. The esophageal wall is complete throughout. It is closely attached to the dorsal body wall with connective tissue in this anterior region, but the attachment is sufficiently flexible to allow the esophagus to be slipped back and forth over the tips slightly, showing that there is no rigid attachment to the bone. This observation was confirmed by study of four specimens from the Chicago Natural History Museum (CNHM 16840, 24906-08). In each the first elongated hypapophysis was found at the level of the tenth ventral scute, and from 21 to 24 such hypapophyses were visible through the wall of the esophagus. However, in none of the specimens examined was there an opening that might allow penetration of the esophagus by an hypapophysis.

Elaphe carinata, therefore, does have specialized hypapophyses on some of the anterior vertebrae that would, no doubt, aid in its feeding on the eggs of large birds (though its reported food is mainly reptiles, *vide* Pope, 1935, The Reptiles of China, p. 237). However, these hypapophyses do not penetrate the wall of the esophagus to act as cutting structures as suggested by Gans (*supra cit.*). The modifications for egg-eating appear to be at about the level as that reported for *Elaphe climacophora* by Gans and Oshima, and thus does not approach the level of specialization found in *Dasypeltis* (and variously reported for the Asian *Elachistodon*). The subfamily Dasypeltinae, therefore, appears to remain distinctive on this basis.

I wish to thank the curators of the institutions who allowed me to make these observations on specimens in their care: Dr. Norman Hartweg and Dr. Charles F. Walker, University of Michigan Museum of Zoology, and Dr. Robert F. Inger and Mr. Hymen Marx, Chicago Natural History Museum. I also wish to express my appreciation to Dr. Guerdon D. Nichols, Dean of the College of Arts and Sciences, University of Arkansas, and to the National Science Foundation (NSF-G4443) for making possible the visits to these institutions.—HERNDON G. DOWLING, *University of Arkansas, Fayetteville, Arkansas.*

NOTES ON THE PRESENT HERPETOFAUNA OF ASCENSION ISLAND.—Shortly before the end of World War II, Dr. C. M. Bogert sent me a *Liolaemus* captured by Dr. J. P. Chapin on September 28, 1942, during his brief visit to Ascension Island, South Atlantic. The specimen, A.M.N.H. No. 64806, has been identified by Dr. R. G. Zweifel as *L. wiegmanni*. On October 28, 1945 Dr. Chapin informed me that he had been informed by Mr. Tomlinson, the then District Commissioner of Ascension, that frogs of the genus *Xenopus* were also present. A specimen of *Xenopus* collected by Mr. Tomlinson in October 1944 is in the collections of the American Museum, No. 52573.

Through Miss A. G. C. Grandison of the British Museum and Capt. H. L. Holland of the R. M. S. Braemar Castle, permission was obtained from Mr. A. R. Harrison, the Administrator, for my wife and me to land on Ascension when the steamer called there on October 7, 1957. As our time ashore was limited to 2½ hours, Mr. Harrison had arranged with his colleague, Mr. J. R. Bruce, to drive us up from the lava-strewn littoral to where there was at least some scanty vegetation in the shape of cactus, scattered scrub and occasional palms.

There, in the course of an hour (10–11 AM), we managed to secure 3 male and 5 female *Liolaemus* which Mr. J. C. Battersby of the British Museum subsequently identified for me as *L. wiegmanni* (Dumeril and Bibron). I believe this was the provisional determination that I put on the Chapin specimens with the reservation that the *wiegmanni* of Boulenger's catalogue might be somewhat of a composite.

Each of my three males had 5 preanal pores; their midbody scale rows numbered 48, 48 and 52 respectively. The last figure was around the largest male, which measured 128 (63 + 65) mm. His coloration, shortly after death, was as follows: Above, gray brown variegated with sepia which, on the nape, took the form of two anteriorly convergent parallel lines, followed on the dorsum by paired blotches that tend to converge on the tail to form a median line posteriorly; snout and upper lip, eyelid and a pale dorsolateral band extending from back of eye to base of tail, tinged with reddish orange; below this dorsolateral band the flank is a rich velvety black, especially anteriorly; from axilla to groin there are orange-red flecks. Below, chin orange-red; rest of undersurface white to creamy white

lightly tinged with an orange-red blush on throat and abdomen; on each femur is a lemon-yellow to buffish streak three or four scales in width; tail creamy white.

All five adult females were without pores, their midbody scale rows numbered 48, 48, 50, 50, and 52 respectively. In one female the ova were minute, two of the others held 3 eggs each and two held 4 eggs each; in size these eggs ranged from 5 x 5 mm. to 7 x 13 mm. The largest female measured 125 (61 + 64) mm. Her coloration, shortly after death, was as follows: Above, gray brown variegated with sepia which, on the nape, took the form of two parallel lines, followed on the dorsum by semi-lunar-shaped, paired blotches backed by light spots that, on the tail, tend to converge in a series of V-shaped markings which may coalesce to form a dark line posteriorly; eyelids whitish, while from behind each eye in the post-parietal region arises a pale buff dorsolateral band that extends backwards to base of tail; below this is a series of sepia and white markings, still lower, from axilla to groin, a longitudinal cream or buff line. Below, white or slightly stained, uniform.

The brighter color of the males was inconspicuous, when, disturbed by the removal of some sheltering palm frond or other debris, they darted through the dusty soil for a few feet before, characteristically pausing in the shade of some bush or cactus. In their stomachs four or five orders of insects were present. For their identification I am indebted to the following entomologists on the British Museum staff: Dr. D. R. Ragge (Orthoptera); Dr. R. V. Izzard (Hemiptera); Dr. Allan Watson (Lepidoptera); and Miss C. M. F. von Hayek (Coleoptera).

The stomach contents included heads, parts of pronotum, abdomen and wings of cockroaches (Blattoidea, or Blattaria *auct.*); male forewings and part of femur of a cosmopolitan cricket (*Gryllodes sigillatus* Walker). *Nysius thymi* Wolff, a widely distributed member of the Lygaeidae occurring in both Paleartic and Nearctic regions as well as the Atlantic Islands. A large lepidopterous larva of the family Noctuidae and a small indeterminate Microlepidoptera larva. A coleopterous larva, possibly that of an elaterid or tenebrionid; two or three species of Tenebrionidae and a coccinellid—*Cheilomenes lunata* Fab.

Though *Liolaemus* occurs at sea level on Ascension Island, it was at an altitude of approximately 1000 feet where ours were collected. Mr. Bruce then drove us on up Green Mountain to Convalescent House, situated at 1800 feet, telling us that geckos occurred there. As we went, the ever-increasing mist turned to fine rain, the sky was overcast and it seemed too chilly for reptiles. Mrs. Stevens, wife of the caretaker, conducted us to the kitchen on whose smoke-blackened rafters geckos appeared at night. At the time of our brief visit there were none to be seen, but Mrs. Stevens said that her son had found a pair of eggs under a stone in the garden. The youngster showed them to me *in situ* and I was allowed to remove them.

During the six months these eggs have been in my possession they have failed to hatch, but their measurements—8 x 9.5 mm.—are identical with those of a pair taken November 10, 1957, on St. Helena, where *Hemidactylus frenatus* (Dumeril & Bibron) of Java has probably been established since the days when it was a port of call for the Dutch East Indiamen. In 1875 it was reported as present at low levels on St. Helena by Mr. J. C. Mellis (St. Helena, 1875, p. 99), a reference omitted from my revision of African Gekkonidae. Its occurrence on Ascension Island is, I believe, now reported for the first time, but how and when the introduction took place I have no information.

As for the *Xenopus*, I was told by Mr. Harrison that the time at my disposal would not permit of my visiting the artificial dew pond where they are established, for Green Mountain is 2817 feet above sea level and the pond is situated not far from the summit. However, Mr. Harrison introduced me to Mr. P. Critchley, Farm Manager for Cable and Wireless, who kindly promised to secure some of the frogs for me. On February 26, 1958, eight of these *Xenopus* reached me on St. Helena, which is some 750 miles southeast of Ascension Island.

The four males (assumed, for only one of each sex was dissected) measure from 41 to 55 mm., the four females from 65 to 75 mm. (snout to anus). When viewed from above their black claws appear flattened as in *X. l. laevis* (Daudin) of South Africa, but while the undersides of the males are normal, being immaculate white, those of the females are flecked or spotted with gray or black as in the round-clawed *X. l. victorianus* Ahl of Central Africa, a form that is but slightly distinguished from the heavily vermiculated *X. l. petersii* Bocage of Angola. The probability is that these Ascension frogs were introduced from South Africa during World War II, when the species was in such demand for diagnostic purposes.—ARTHUR LOVERIDGE, *Varneys, St. Helena Island, South Atlantic Ocean.*

NOTE ON THE BREEDING OF THE SOUTH AFRICAN SKINK, *TYPHLOSAURUS LINEATUS* BOULENGER.—Very little has been recorded concerning the biology of skinks of the

genus *Typhlosaurus*, a small group of limbless burrowing lizards endemic to Southern Africa. The species in question (*T. lineatus*) occurs in the dry sandveld country of the Kalahari and can usually be obtained by digging in the loose windborne sand under bushes at such places as Twee Rivieren in the Kalahari Gemsbok Park. A number of specimens has been obtained from this locality from time to time, and on February 20, 1958, Dr. G. van Son of the Transvaal Museum collected two females there, both gravid. One gave birth to its young on being immersed in alcohol. Each female was found to contain one young only, obviously fully formed and remarkable for their great length in proportion to that of the adult females. Lengths are as follows: Female 138 mm.; young 71 mm.: Female 137 mm.; young 74 mm.

Each young was carried with its head directed posteriorly while the tail, which pointed anteriorly was folded back upon itself for a length of about one centimeter. In colour and markings the young were practically identical to the adults. Stomach contents of *Typhlosaurus lineatus* from the Kalahari suggest that these lizards feed almost exclusively on termites.—C. K. Brain, *Department of Lower Vertebrates, Transvaal Museum, Pretoria, South Africa.*

A MINIMUM EGG COMPLEMENT FOR THE WESTERN MUD SNAKE, *FARANCIA ABACURA REINWARDTI*.—On June 25, 1958 at 10 AM CST a *Farancia abacura reinwardti* was collected 4.1 miles west of the Liberty Hill Fire Tower on Farm Road 943 in southeastern Polk County, Texas. The total length before preservation was 927 mm.; the tail 101 mm.

Dissection revealed four well-developed eggs in the right oviduct. Approximate measurements of these eggs after alcoholic preservation are as follows: 40.0 x 20.9 mm., 42.2 x 18.4 mm., 40.0 x 19.6 mm., 42.0 x 19.5 mm. In the posterior portion of the left oviduct were two dark yellow firm ellipsoids which were considered infertile eggs. One measured 33.0 x 16.0 mm. and the other was brittle and crumbled before measurement was taken. Previously I had observed a firm yellow ellipsoid, similar in appearance to those described above, among a complement of fertile eggs laid by a *Heterodon platyrhinos* in my possession. Riemer (1957, Herpetologica, 13: 31-2), in describing a natural nest of a *Farancia* near Gainesville, Alachua County, Florida, stated that 36 collapsed shells were evident but that no infertile eggs were present.

According to Wright and Wright (1957, Handbook of Snakes, Cornell University Press, vol. 1, p. 278) the number of eggs recorded for *Farancia a. reinwardti* ranges from 11 to 50. These authors state that the minimum number of eggs was observed in 1883 by Ridgway who found a *Farancia* with 11 eggs at Wheatland, Indiana. Wright and Wright (*op. cit.*) list 15–104 as the range of egg complements for *Farancia a. abacura*.

This report thus constitutes a new minimum egg number for *Farancia abacura* and the minimum and maximum egg complement for the species may be presently stated as 6–104. Such a wide range is presumably correlated with the wide range in body size of sexually mature individuals.—J. P. Kennedy, *Department of Biology, University of St. Thomas, Houston, Texas.*

MATING IN THE SOUTH AFRICAN MOLE SNAKE, *PSEUDASPIS CANA* (LINNAEUS).—The object of this note is to record a mating that occurred between two mole snakes in which both hemipenes of the male were used simultaneously. The snakes, belonging to Mr. J. Malan of Pretoria, were of two colour forms, the male from the Western Cape Province being pure black, while the Transvaal female was brown. Both were more than five feet in length.

In February 1958 the mating was observed and it was then noticed that both hemipenes had

Fig. 1. The hemipenes of a black mole snake. In the mating described here both hemipenes were used simultaneously. Photograph by P. Engelbrecht.

been inserted into the cloaca of the female. The snakes were separated and a photograph (Fig. 1) was taken. The hemipenes were each wound corkscrew-like and on removal from the female cloaca the coils of the one hemipenis were closely adpressed to those of the other. The hemipenes were not interwound.

It is not possible to state whether the simultaneous use of both hemipenes by the mole snake is a usual or exceptional occurrence. It is known that very large litters of young are sometimes produced, one of 84 being on record. A litter of this size must certainly be the result of a very efficient copulation and there is little doubt that the chances for fertilization would be enhanced by the use of two, rather than one hemipenis.

The writer is indebted to Mr. J. Malan for providing information.—C. K. Brain, *Department of Lower Vertebrates, Transvaal Museum, Pretoria, South Africa.*

A SIMPLE METHOD OF COLLECTING *ASCAPHUS TRUEI* TADPOLES.—It is well known that the tadpoles of *Ascaphus truei* occur in shallow rapid flowing mountain streams whose temperature may only be a few degrees above freezing. The usual method of securing specimens is to wade out into the cold water and laboriously turn over every rock. The tadpoles hold onto these rocks with their enlarged mouth parts and by dexterous movements will drop into collecting jars if one is fast enough. Too often however the tadpoles will drop back into the rapid moving water and be lost even before one has had a good look at them.

While studying may-fly larvae in a stream where *Ascaphus truei* had been found previously I was surprised at the ease, simplicity and rapidity with which the tadpoles could be successfully collected. All one has to do is to place an insect net down into the bottom of the stream with the opening facing upstream. When the rocks in front of the net opening were picked up the debris collected in the interstices was disturbed and this material together with the accompanying tadpoles was collected in the bag of the net. Within half an hour eight tadpoles were collected by this method even though not a single specimen was actually seen on the rocks themselves.

This method I am sure would be successful for collecting not only *Ascaphus*, tadpoles but for other amphibian larvae that have similar habitat preferences.—Arthur Svihla, *University of Washington, Seattle, Washington.*

AGGRESSIVE BEHAVIOR IN *PLETHODON JORDANI*.—Lehrman (1956, Ann. Rev. Physiol., 18:537) has pointed out that an important development during recent years "has been the increasing appreciation of the specificity with which behavior patterns characterize taxonomic groups at all levels". Such a development is valuable not only to workers interested in animal behavior but also to systematists and evolutionists. Undoubtedly, many interesting and possibly important observations on behavior in amphibians have been made by collectors and field workers but were possibly overlooked as being of no importance. If such observations are recorded in the literature, we may eventually be able to utilize behavior patterns more fully in the study of the group.

Test (1954, Science, 120: 140) has reported social aggressiveness as a means of maintaining territoriality in the South American frog, *Phyllobates trinitatis*, and Martof (1953, Ecology, 34: 165) has suggested that breeding groups of *Rana clamitans* exhibit a weak territoriality. To my knowledge, observations on aggressive behavior in other amphibians have been rarely recorded, if at all.

One such observation was made on July 15, 1957, at 10:30 PM at an elevation of approximately 5400 ft. on Grandfather Mountain, Avery County, North Carolina. Two males of *Plethodon jordani metcalfi* were observed to engage in a "fight" on an almost vertical rock face. The two animals were in shallow crevices, one crevice approximately two inches above the other. The salamanders were facing in opposite directions when first seen in the light of a headlamp and the male in the upper crevice was moving obliquely over the rock face toward the lower crevice. This animal then bit the lower salamander on the dorsum between the hind limbs, turned, and moved in the opposite direction along the crevice it originally occupied. The salamander in the lower crevice immediately crawled up the rock and bit the retreating individual near the base of the tail, then proceeded to follow the retreating animal for approximately six inches, when both animals stopped moving. No further action was apparent after a few minutes, and both animals were collected and identified as males due to the pointed lower jaws and small, though prominent, mental glands.

A similar type of behavior was observed by Joseph R. Bailey in *P. j. shermani* in August, 1947, at approximately 4000 feet on Wayah Bald, Macon County, North Carolina (personal communication). Two of these salamanders (sex unknown) were observed about one foot from each other on the forest floor. One individual then

approached the other from behind and a little to the left and bit the other on the back. Whether or not these actions indicate a type of territoriality is problematical.—VICTOR H. HUTCHISON, *Department of Zoology, Duke University, Durham, North Carolina.*

USE OF THE CHICK IN ZOOTOXICOLOGIC STUDIES ON VENOMS.—The mouse is the animal of choice for determining the dosages yielding 1–99 percent (LD_1–LD_{99}) average mortality for most drugs. During studies on the zootoxicologic effects of certain animal venoms (Russell and van Harreveld, 1954, Arch. Internat. Physiol., 62: 322; Russell, Panos, Kang, Warner and Colket, 1958, Am. Jour. Med. Sci., 235: 566) it was found that in the determinations of the LD_{50}, ED_{50} and ALD the chick was a more satisfactory test animal than the mouse. The chick has fewer non-specific sudden lethal reactions, is less expensive to purchase and maintain and, in most areas, is more readily obtainable than the mouse. The rapid growth and weight change in the chick, during the first few months of life, is also advantageous where information is desired regarding the lethal dose of a venom as a linear function of body weight (mg./kg.). The present report treats with the LD_{50} in the chick and mouse of several venoms as determined by the intravenous and intraperitoneal routes.

Swiss albino mice, weighing between 20–30 gm. and White Leghorn chicks, weighing between 40–110 gm. were used in all experiments. Approximately 1400 animals were tested of which 926 were used in the statistical analysis, or about 50 for each determination. The venom was prepared from a single lot of the dried product of each species of snake and was injected in a physiological solution. In the mouse the intravenous dose was made through a tail vein while in the chick the intravenous injection was made through the axillary vein in one wing. The total volume of venom injected intravenously never exceeded 0.3 ml. Death within 24 hours was taken as the criterion for the lethal determination.

A simple method for intravenous injections in the chick is to place the animal in a supine position on a board with one length of rubber tubing fit across the malleolar regions and a second length placed loosely across the neck. The wing may then be extended, the puncture area swabbed with alcohol and the venom injected through a 30 gauge needle. Extravasation of the venom can easily be seen. In the present series, only those animals which received a complete intravenous injection were retained in the experiment.

Table 1 shows the LD_{50} values and 19/20 confidence limits of 5 venoms expressed in mg./kg. of test animal body weight after the method of Litchfield and Wilcoxon (1949, J. Pharmacol. & Exper. Therap., 96: 99). In mice the LD_{50} values for the intravenous and intraperitoneal routes of the Crotalidae venoms do not show a statistical difference at the .05 level of confidence. Only with the venom of *Ancistrodon piscivorus* is there a small statistical difference in the LD_{50} between the two routes. In the chicks, the LD_{50} for all of the venoms is increased when the intraperitoneal route is used.

TABLE I

LD_{50} AND 19/20 CONFIDENCE LIMITS IN MG./KG. TEST ANIMAL BODY WEIGHT

Venom	Intravenous Mice	Intraperitoneal Mice	Intravenous Chicks	Intraperitoneal Chicks
Crotalus adamanteus	1.68 (1.43–1.98)	1.89 (1.63–2.19)	1.18 (0.89–1.58)	2.38 (2.12–2.67)
Crotalus atrox	4.20 (3.85–4.55)	3.71 (3.50–3.90)	0.98 (0.78–1.22)	4.55 (4.27–4.84)
Crotalus horridus	2.63 (2.36–2.91)	2.94 (2.72–3.18)	0.59 (0.50–0.69)	3.71 (3.40–4.04)
Ancistrodon piscivorus	4.00 (3.42–4.68)	5.11 (4.49–5.82)	0.91 (0.76–1.12)	1.26 (1.03–1.54)
Ancistrodon contortrix	10.92 (9.58–12.45)	10.50 (9.50–11.55)	1.79 (1.40–2.29)	8.12 (6.49–10.15)

It will also be noted that the chick is more susceptible than the mouse to the lethal effects of the venoms when the intravenous route is used. When the intraperitoneal route is used the mouse is more susceptible to the lethal effects of the Crotalidae venoms while the chick is more susceptible to the lethal effects of the venom of *Ancistrodon piscivorus* and *Ancistrodon contortrix*. In determining the dose-weight relationships some linear correction factor had to be employed. These relationships were evaluated critically as suggested by Rall and North (1953, Proc. Soc. Exp. Biol. & Med., 83: 825).

The data indicate that the chick may be preferred to the mouse for determinations of the LD_{50} of a venom. While a difference in the LD_{50} between the two animals exists, it may not be significant when information is needed in deter-

mining the lethal dose for another animal or man. The difference in tolerance between the two animals is probably not significant in evaluating the effective dose of the venom for the study of certain biological activities. Supported by a grant from Smith, Kline and French Foundation.—FINDLAY E. RUSSELL and JERRY A. EMERY, *Laboratory of Neurological Research, College of Medical Evangelists, Los Angeles County Hospital, California.*

Ichthyological Notes

AN OBSERVATION ON THE DEEP-SEA ELECTRIC RAY.—*Benthobatis marcida* Bean and Weed, a member of the family Torpedinidae, belongs to a genus that is bathybenthic. The genus has been taken from depths ranging from 150–585 fathoms off the coasts of South Carolina, Florida, Cuba, Travancore in India and the eastern side of the Arabian Sea. Bean and Weed (1909, Proc. U. S. Nat. Mus. 36: 677) described this species from material collected off the Florida coast. Garman (1913, Mem. Harv. Mus. Comp. Zool. 36: 295) reported on further material from Cuba. Bigelow and Schroeder (1953, Fishes of the Western North Atlantic, Memoir No. 1, pt. 2, Sears Foundation for Marine Research: 128–132) summarized the available information known about the species and made the statement that the developmental stages have not been observed.

A single female was taken by otter trawl by the Fish and Wildlife M/V *Delaware* on 23 February, 1958, 27 miles SSW of Diamond Shoal Light (on a course between Lat. 34° 40′ N, Long. 75° 32′ W and Lat. 34° 41′ N, Long. 75° 31′ W) at a depth of 200–250 fathoms.

The total length was 435 mm. The following measurements are given as percentages of the total length: disc breadth, 43.6, length, 46.6; snout length, 11.4; eye diameter, 0.4; spiracle length, 2.5, distance between, 8.0; mouth breadth, 5.3; distance, tip of snout to center of cloaca, 44.1, center of cloaca to tip of tail, 55.9.

Both ovaries were coarsely spongy structures, equal in size and each approximately 20 mm in diameter. There were numerous small eggs showing at the surface, measuring about 2 mm. in diameter when dissected out. The nidamental glands appeared to be absent. The lining of the oviducts formed narrow rugi. Strong sphincter muscles separated the oviducts from the uteri. A second sphincter muscle was located where each uterus opened into the cloaca. Each uterus appeared to have one large egg. It probably represented 2–3 eggs closely juxtaposed. This supposition is based on the overall size of each ovary and the ovarian eggs as well as the eggs found in the uteri of other rays. There was no evidence of egg capsules. Each egg mass was more or less oval in shape. The greatest dimension for the egg mass in the left uterus was 29 x 41 mm., 30 x 41 mm. in the right. Each egg mass had a light lemon yellow covering of a pasty consistency about 1 mm. thick (animal preserved in formalin). The color in life tended to be more orange. Beneath this layer the yolk material was whitish and was more or less laid down in layers. There was no evidence of developing embryos. The walls of the uteri were greatly distended and thin. There was no evidence that the lining of the uteri formed villi or rugi; nor was there evidence of extensive vascularization in the fresh or preserved condition. The apparent absence of nidamental glands and placentae resemble the condition found in *Narcina indica* (Prasad, 1945, Proc. Nat. Inst. Sci. India 11 (3): 282). The absence of nidamental glands, egg capsules, placentae or villi and the smooth and plain condition of the uteri are also similar to *Narke dipterygia* (Setna and Sarangdhar, 1952, Jour. Zool. Soc. India 3: 311). These characteristics would suggest a different form of dependence on the parent for nourishment by the developing embryos than has been observed for other rays (*Pteroplatea, Dasyatus*). This latter genus has villi-like trophonemata formed at the time the eggs enter the uterus.

The stomach was empty.

Thanks are due to Stewart Springer and James L. Squire, Jr. both of the Fish and Wildlife Service, for providing facilities aboard the M/V *Delaware* and for making the specimen available. This work has been supported by a National Science Foundation Research Grant, NSF-G4393. Marine Laboratories Contribution No. 8.—FRANKLIN C. DAIBER, *University of Delaware, Newark, Delaware.*

THE BIGFIN EELPOUT, *APRODON CORTEZIANUS* GILBERT, COMMON IN WATERS OFF OREGON.—The bigfin eelpout, *Aprodon cortezianus* Gilbert, is being taken frequently off Oregon by otter trawlers. Seventeen speci-

mens, four females and 13 males, are in the fish collection of the Department of Fish and Game Management, Oregon State College, Corvallis, Oregon. According to fish handlers at Newport, Oregon, the bigfin eelpout appears to be most numerous in trawl catches during July and August, when specimens are in nearly every catch. Most individuals are taken at depths of 80 to 150 fathoms.

In Table I are presented data on Oregon specimens of *Aprodon cortezianus*.

Gilbert (1891, Proc. U. S. Nat. Mus., 13: 107) originally described *Aprodon cortezianus*, the only member of the genus, from six specimens taken at Albatross stations 2925 and 2948 in 339 and 266 fathoms on Cortez Banks off San Diego, California. We are aware of nine additional California collections; they range from off San Diego to Point Arena in 191 and 339 fathoms (*ibid.*, Gilbert, 1895, U. S. Comm. Fish and Fish., Rept., 19(6): 455, 470; Gilbert, 1915, Proc. U. S. Nat. Mus., 48: 361; Bayliff, 1954, M. S. thesis (unpublished) Univ. Wash.: 56–58). Although there are numerous records from California, only three collections of single specimens have been reported from north of California, and none reported from Oregon. Starks (1926, Stanf. Univ. Publ. Biol. Sci., 4(3): 311) lists a specimen from Alaska, but this record cannot be verified (Palmen, 1954, Fish. Res. Pap., Wash. Dept. Fish., 1(2): 45). Brock (1943, *Copeia*, (3): 45) reported a single specimen taken in 60–65 fathoms off Washington between Willapa Bay and the Columbia River; and Carl and Wilby (1945, Canad. Field Nat., 59(1): 29) reported an adult female taken at 50 fathoms in Barkley Sound, British Columbia. A further extension of the northern range was established by Palmen (1954, *op. cit.*: 45) from one specimen captured at a depth of 100 fathoms approximately 40 nautical miles southwest of Hekai Pass, Queen Charlotte Sound, British Columbia.

Following are counts and measurements of the 17 Oregon specimens. Each count is given, followed in parentheses by the number of fish showing that count. The mean of the measurements is given, followed by the range in parentheses. The dorsal ray counts plus the number of upper caudal rays are given, as are the anal rays plus the lower caudal rays. The caudal ray counts refer to rays associated only with elements of the last vertebra.

Some discrepancies between the characteristics of the specimens considered here and those presented in the original description and other papers were noticed in the counts of gill rakers, pectoral, anal, and dorsal fin rays. The coloration and morphological characteristics agreed fairly well. Gilbert (1891, Proc. U. S. Nat. Mus., 13: 107) reported 15 gill rakers, and 20–21 pectoral rays in the original description of six specimens from off San Diego, California, and Bayliff (1954, *op. cit.*: 57) reported 19–20 pectoral rays in material examined from Washington and California. The anal ray counts of the Oregon specimens shown in Table II are higher than reported by Bayliff (*ibid.*), but agree with those given by Clemens and Wilby (1949, Bull. Fish. Res. Bd. Canada, 68: 192). The dorsal ray counts of the Oregon material are slightly lower than the

TABLE I

NINE COLLECTION RECORDS OF 17 BIGFIN EELPOUTS, *Aprodon cortezianus*, FROM OREGON[1]

OSC Coll. No.	No. Specs.	Date	Locality
295	1	VII:16:1954	Found dead on beach. Lincoln Co.
292	1	VIII:3:1955	Off Newport
297	2	Summer 1955	Out of Astoria
291	1	IV:30:1956	Off Oregon 150–235 fathoms
296	1	VI:20:1956	WSW Yaquina R. 140 fathoms
293	1	Summer 1956	Between Columbia R., and Newport
318	5	VII:21:1958	Between Cascade Head and Yaquina Head 80 fathoms
294	4	—	Off Oregon
317	1	—	Off Oregon
	17		

[1] All specimens but OSC 295 were sorted from otter trawl catches transported to Corvallis, Oregon for use as mink food.

TABLE II

COUNTS AND MEASUREMENTS OF *Aprodon cortezianus* FROM OREGON

Character	No. Specs.	
D. plus upper c. rays	10	105 + 7 (2); 106 + 7 (2); 107 + 7 (6)
A. plus lower C. rays	10	89 + 6 (3); 89 + 7 (2); 90 + 66 (4); 90 + 7 (1)
Pectoral rays	17	18–18 (1); 18–19 (1); 19–18 (2); 19–19 (13)
Pelvic rays	7	3–3*
Gill rakers	10	16 (8); 17 (2)
Standard length	17	421.3 mm. (320.5–485.0 mm.)
Total length	17	428.0 mm. (327.0–493.5 mm.)
SL/Body depth	17	7.9 (6.8–9.4)
SL/Head length	17	4.3 (4.0–4.7)

* Ten of the 17 specimens had one of the two pelvic fins missing, or apparently mutilated, but when the rays could be counted with certainty there were always three present in each fin.

counts given by Clemens and Wilby (*ibid.*), but correspond well with the counts given by Bayliff (1954, *op. cit.*: 57).

Two females (405.0 and 440.1 mm. SL), OSC collection 318, were examined before preservation. The ovaries appeared fully developed and contained ova which measured from 5.2 to 6.0 mm. in diameter. Two preserved females (320.5 and 406.5 mm. SL), OSC collection 293 and 297, had undeveloped ovaries; the ova measured from .6 to 1.0 mm. in diameter. One partially spawned and two additional mature females were collected WSW of Newport, Oregon, August 20, 1958. Samples of ova from all three fish ranged from 6.0 to 6.1 mm. in diameter. Comparison of sexual development with the collection dates of females examined indicates that this eelpout spawns in late summer or early fall.—J. B. Bali and Carl E. Bond, *Department of Fish and Game Management, Oregon State College, Corvallis, Oregon.*

OBSERVATIONS ON AGGRESSIVENESS IN SOCKEYE SALMON SMOLTS.—Juvenile sockeye salmon are usually strongly schooling fish (Hoar, 1954, Jour. Fish. Res. Bd. Canada, *11*(1): 72). However, during laboratory observations on the behavior of juvenile salmon, aggressiveness in sockeye smolts was noted on several occasions. Hoar observed this too (*op. cit.*), stating that nipping by sockeye smolts does not have the vicious appearance of coho nipping and never elicits a retaliation.

In the Fish Behavior Laboratory, United States Fish and Wildlife Service, Seattle, Washington, we conducted tests which confirm this observation and suggest that this behavior is defense of territory.

Three individuals were removed from a group of schooling sockeye smolts and placed in a three-chambered tank. They were allowed to adjust over night, then a fourth individual was introduced. There was no immediate response, but soon one of the "resident" fish cautiously approached the newcomer, then swam away. This took place several times until the newcomer turned away. The resident fish renewed his motions which then began to have a menacing air. Usually the newcomer took flight and chase was given by the aggressor. The chase was of short duration and seldom, if ever, seemed to involve any bodily contact. On one occasion, however, with some very silvery smolts, there was biting or nipping and numerous scales were observed floating in the water.

The unwelcome stranger was usually displaced over a sill into another chamber where the process was repeated. The initial resident was not always successful; at times the intruder also made menacing moves and in some instances drove out the resident.

Fish which have been engaged in this chasing activity, when transferred to a larger, undivided tank containing several other fish, again schooled. Therefore, spatial relationships, container size, and numbers of fish appear to influence this behavior.

Having repeated this with young sockeye which had varying lengths of time in "residence" in the experimental tank, we believe that the aggressiveness is reinforced with more time in the chamber. Fish that were in the chambered tank for three days actually made bodily contact and produced abrasion, while other groups that were acclimatized either over night or for a few hours prior to adding the extra fish usually just chased the intruder.

Behavior of this type is of more than passing interest and must be taken into account when designing experiments which utilize small sized samples of fish. A sequence of this behavior has been filmed for future reference and study.—H. William Newman, *United States Fish and Wildlife Service, Bureau of Commercial Fisheries, Seattle, Washington.*

THE OCCURRENCE AND FOOD OF THE SLEEPER SHARK, *SOMNIOSUS PACIFICUS*, IN A CENTRAL ALASKA BAY.—A single specimen of the sleeper shark, *Somniosus pacificus* Bigelow and Schroeder, was taken on June 3, 1958, in Kachemak Bay, Cook Inlet, Alaska. It was shot after being trapped in a small pot hole off Ismailof Island where the surrounding area was exposed on a minus tide.

As far as can be determined no record for this area has been previously reported. The sleeper shark was first recorded from British Columbia waters. Since that record, individuals have been reported from the Sea of Japan, Bering Sea, south-eastern Alaska, and as far south as California (1946, Clemens and Wilby, Fish. Res. Bd. Can. Bull. 67: 60–61).

The specimen, a female, measured 3.45 meters (136 inches) from the tip of the snout to the end of the vertebral column, with a total length of 3.93 meters (155 inches). The general body color was black mottled with white, which gave away to gray on the ventral surface. The liver was an extremely attenuated structure, with a total weight of 400 pounds. The weight of the specimen was estimated as a ton.

The digestive tract yielded the following contents: Portions of at least three harbor seals, *Phoca vitulina*; three complete octopi, *Octopus* sp.; fragments and complete individuals of tanner crabs, *Chionoecetes bardi*; fragments of the hairy

triton, *Fusitriton oregonensis*; and a large volume of unidentifiable material.—DONALD B. BRIGHT, *Department of Biology, University of Southern California, Los Angeles, California.*

SEVERAL FISHES NEW TO FLORIDA FRESHWATERS.—The following four sunfishes, the white bass and the yellow perch have been taken recently from the freshwaters of western Florida and deserve inclusion in the Florida list. The shortnosed sturgeon from eastern Florida re-establishes an old record long considered by many as doubtful. Specimens are cataloged in the University of Florida Collections.

Micropterus coosae Hubbs and Bailey. Redeyed bass. A sizeable population exists in the rapids of the Chipola River, Jackson County, where local fishermen have long known it as the shoal bass. We are indebted to Dr. Reeve M. Bailey for the identification of specimens.

Lepomis cyanellus Rafinesque. Green sunfish. Known in Florida only from specimens taken at Sneads Landing, Jackson County, where the fish appears to be well established in Lake Seminole.

Lepomis humilis (Girard). Orangespotted sunfish. Occurs with the green sunfish at Sneads Landing but in lesser abundance.

Pomoxis annularis Rafinesque. White crappie. Specimens of white crappie were taken in several sizes from the Apalachicola River, Gadsden County, immediately below the Jim Woodruff Dam. The black crappie, *Pomoxis nigro-maculatus* (Le Sueur) occurs abundantly in the area of the reservoir and to a lesser extent in the river below the dam. Thus, the future fates of these two populations warrant attention in the area where they now occur sympatrically.

Perca flavescens (Mitchill). Yellow perch. Specimens up to almost fourteen inches in total length have been collected from the Apalachicola River immediately below the Jim Woodruff Dam, Gadsden County. Although far south of the accepted range for the yellow perch, the reservoir above the dam may prove suitable for the establishment of the species.

Roccus chrysops (Rafinesque). White bass. In the tailrace of the Jim Woodruff Dam, Gadsden County, fishermen have been taking white bass in numbers and some have been caught in the reservoir. Specimens of eight to ten inches standard length are common but others which weighed up to about three pounds have been reported.

Acipenser brevirostris Le Sueur. Shortnosed sturgeon. This species was incorporated in Florida's faunal list by Evermann and Bean (Indian River and its fishes. Rept. U. S. Fish Com. 1896 (1898)) and apparently all subsequent reports stem from this original record. In recent years authors have been inclined to exclude Florida from the range of the species. This is possibly because, since only the common sturgeon, *Acipenser oxyrhynchus* Mitchill, had been caught in Florida for over half a century, the original record of the shortnosed form was considered erroneous. However, one adult *A. brevirostris* (UF-5714) was taken in 1949 by commercial seine from Big Lake George, St. John's River, and donated to the University of Florida Collections by Dr. William M. McLane who expressed the well-founded belief that currently this species, as well as *A. oxyrhynchus*, is extremely rare on the Atlantic Coast of Florida. (McLane, W. M., Fishes of the St. Johns River System, Unpub. Doctoral Dissertation, Univ. of Fla. Library, 1955).

Discussion.—The appearance of the several species new to western Florida, where much competent collecting has been done over the years by a number of ichthyologists, demands some sort of comment, if not explanation. The case of the redeyed bass appears clear. Here is a long established but isolated population of an upland form which, insofar as known, has been able to survive in Florida only in a short stretch of clear rapids in a single stream. A detailed study would be required before one could go further and hypothesize on the length of the period of isolation or on the factors involved in the past geographic and ecological distribution of the species.

On the other hand, the presence of the remaining three sunfishes reported as new is not so clear. All three are from an area in which the total ecology has been modified tremendously by the recent erection of the Jim Woodruff Dam. The dam, where confluence of the Flint and Chattahoochee rivers forms the Apalachicola, lies astride the Georgia and Florida state boundaries near the southeast corner of Alabama. The impoundment at this location, Lake Seminole, should have no appreciable effect on the continued easy access into Florida by fishes of the Flint and Chattahoochee drainages. The effect, however, on the permanent establishment of new forms and changes in population densities is expected to be considerable. Further, the known ranges of these sunfishes have boundaries extending into the proximity of the Flint and Chattahoochee drainages, i.e., the white crappie is known from southern Alabama, the orangespotted sunfish from the Tennessee River system in Alabama, and the green sunfish from the Mississippi basins of Georgia and southern Alabama.

Thus, three possibilities occur. It could be assumed that these three sunfishes could have

been long-time residents but in numbers sufficiently small to be overlooked prior to the mass collecting techniques recently employed by the Florida Game and Fresh Water Fish Commission. Conversely it could be assumed that the presence of these three species is the result of recent invasions by either natural range extensions or through artificial stocking by fishing interests. (We have no affirmative data concerning the artificial stocking of any of these sunfishes.) The third possibility is that, whether they are new arrivals or citizens of long standing, the recent creation of Lake Seminole has presented an opportunity for populations to increase to the level of conspicuousness. It will be of much interest to follow the future course of these three forms in western Florida.

The case of the yellow perch must await future developments. It has been introduced into many drainage systems outside its more northern range and because of some notable successes of those introductions, it is not impossible that the reservoir of the Jim Woodruff Dam may, in time, entertain a breeding population of this species.

The white bass may be the result of artificial range extension. Dr. Royal D. Suttkus, Tulane University, has informed us that this species was introduced, with apparent success, into an Alabama pond within the Escambia drainage several years ago.—JOHN D. KILBY, *Department of Biological Sciences, University of Florida, Gainesville, Florida,* EDWARD CRITTENDEN *and* LOVETT E. WILLIAMS, *Lake and Stream Survey, Florida Game and Fresh Water Fish Commission.*

NOTES ON THE TAXONOMY AND DISTRIBUTION OF CERTAIN ZOARCID FISHES IN THE NORTHEASTERN PACIFIC.—This paper, abstracted from a thesis accepted by the University of Washington College of Fisheries, attempts to clear up some confusion in the taxonomy, records, and ranges of ten species of Zoarcidae occurring between southern Oregon and the Aleutian Islands.

The writer owes thanks to members of the faculty of the College of Fisheries, particularly to Dr. A. D. Welander, who served as faculty advisor for the project, and to Dr. R. Van Cleve, director of the College, who kindly made facilities available for study. Dr. L. P. Schultz and Mr. R. H. Kanazawa of the U. S. National Museum furnished numerous specimens and gave valuable advice. Dr. G. S. Myers and Miss Margaret Storey of the Natural History Museum of Stanford University furnished material, including two paratypes, and Dr. H. R. Hill of the Los Angeles Museum also provided specimens for examination.

Lycodes palearis Gilbert, 1895.—Distribution: Puget Sound, Wash., to the Chukchi Sea and Peter the Great Bay, U. S. S. R. The Oregon record of Andriashev (1937, Explor. Mers Russes, *25:* 292–355) cannot be verified.

Lycodes diapterus Gilbert, 1892.—Distribution: San Diego, Calif., to Bering Island, U. S. S. R. and the Sea of Japan in 30 to 576 fm. Jordan and Evermann (1898, Bull. U. S. Nat. Mus., *47:* 2183a–3136) state that this species was recorded off the coast of Oregon in 685 to 877 fm. by Gilbert (1892, Proc. U. S. Nat. Mus., *14:* 539–566). This record, however, was for *Macrurus pectoralis,* which immediately preceded *Lycodes diapterus* in Gilbert's paper. Jordan, Evermann, and Clark (1930, Rep. U. S. Comm. Fish., *1928* (2): 670 place two records from *Albatross* stations (henceforth designated as Al.) 2892 and 2896 in Oregon instead of California.

Lycodopsis pacifica Collett, 1879.—Distribution: Huntington Beach, Calif., to Afognak Island, Alaska, in 10 to 218 fm. A single specimen (UWCF 6120) was captured at a maximum depth of about 5 fathoms in a 60-foot beach seine at Golden Gardens Beach, Seattle. Another specimen (UWCF 3099), collected by the International Pacific Halibut Commission, is labeled "Alaska: Bering Sea? Unalaska Is. Captains Bay?" Captain's Bay is on the northeastern side of Unalaska Island bordering the Bering Sea. Thus this probably constitutes a new western record for the species.

Lycenchelys jordani (Evermann and Goldsborough), 1907.—Distribution: Cape Blanco, Ore., and Sitka Sound, Alaska. Schultz and DeLacy (1936, Mid-Pacif. Mag., *49* (2): 127–142) place the former record in northern California. The Puget Sound record of Jordan, Evermann, and Clark (*op. cit.*) cannot be verified.

Embryx crotalina (Gilbert), 1891.—Distribution: Santa Barbara Islands, Calif., and Sanak Island, Alaska, in 603 and 483 fm. A specimen from Cape Elizabeth, Wash., 685 fm., Al. 3071, Natural History Museum of Stanford University (henceforth designated as SU) 2755 was included in the study material.

Bothrocara Bean, 1891.—*Bothrocara mollis, Maynea pusilla,* and *Maynea brunnea* were originally described by Bean (1891, Proc. U. S. Nat. Mus., *13:* 37–45). Jordan and Evermann (*op. cit.*) assigned *M. pusilla* to *Bothrocara* and synonymized *Maynea brunnea* with *Bothrocara mollis.* Gilbert (1915, Proc. U. S. Nat. Mus., *48:* 305–380) revived *Maynea brunnea,* creating a new genus, *Lycogramma,* for it, on the basis of lateral line differences. This species, however, is very similar to *Bothrocara molle,* differing from it less than does *B. pusillum. Lycogramma soldatovi*

Schmidt (1950, Trans. Pacif. Comm. Leningr., *6:* 370, the only species originally assigned to *Lycogramma*, is also quite similar to *B. molle*. Therefore *Lycogramma* is synonymized with *Bothrocara*.

Since confusion has existed in identification of the members of this genus, the following key to the species of the northeastern Pacific is presented:

1a. Lateral line present; length of major axis of eye greater or less than length of snout
  2a. One lateral line, on body dorsal to mediolateral line; length of major axis of eye greater or less than length of snout; gill rakers long and pointed
    3a. Length of major axis of eye greater than length of snout
      Bothrocara molle.
    3b. Length of major axis of eye less than length of snout
      Bothrocara remigerum.
  2b. Two lateral lines, upper on body dorsal to mediolateral line, lower on tail running along mediolateral line; length of major axis of eye less than length of snout; gill rakers short and blunt
    Bothrocara brunneum.
1b. Lateral line absent; length of major axis of eye greater than length of snout
  Bothrocara pusillum.

Bothrocara molle Bean, 1891.—Distribution: Point Sur, Calif., at Al. 5699 (Townsend and Nichols, 1925, Bull. Amer. Mus. Nat. Hist., *52*(1): 1–20), Queen Charlotte Sound, B. C., at Al. 2860 (Bean, *op. cit.*), Bogoslof Island, Alaska, at Al. 3634 (Jordan and Gilbert, 1899, U. S. Treas. Doc. 2017, Part 3, Art. 18: 433–492), and Avacha Bay, U. S. S. R., at Al. 4797 (Gilbert and Burke, 1912, Bull. U. S. Bur. Fish., *30:* 31–96) in 659 to 876 fm. Specimens from the following additional localities have been examined: Ensenada, Mexico, 984 fm., Al. 2919, SU 290; Cape Elizabeth, Wash., 859 fm., Al. 3075, U. S. National Museum (henceforth designated as USNM) 53062; Cape Flattery, Wash., USNM 54356.

The similarity of this species to *B. brunneum*, plus the fact that they were considered synonymous from 1898 to 1915, has resulted in much confusion in the records for the two species. The record of Jordan and Evermann (*op. cit.*) for Unalaska in 316 fm. cannot be verified for either species. Gilbert and Burke (*op. cit.*) published records for *B. molle* at Bowers Bank, Bering Sea (Al. 4775), and Avacha Bay, U. S. S. R. (Al. 4797). Taranetz (1933, Bull. Far-East Br. Akad. Sci. U. S. S. R., *1933* (1–3): 67–78) thought that the Avacha Bay specimen was *B. brunneum* (then called *Lycogramma brunnea*). Examination by the writer showed that the Avacha Bay specimen is *B. molle* while the Bowers Bank specimens are *B. brunneum*. The specimen recorded as *B. mollis* by Townsend and Nichols (*op. cit.*) at Point Piedras Blancas, Calif. (Al. 5697, American Museum of Natural History 12872) is really *B. brunneum*, according to Dr. V. Walters, who has kindly examined it. The other specimen listed by Townsend and Nichols (*ibid.*) as *B. mollis* (Point Sur, Calif., Al. 5699, USNM 87573) was correctly identified, according to Mr. R. H. Kanazawa. Jordon, Evermann, and Clark (*op. cit.*) erroneously give the holotype locality for *B. molle* as a record for *B. brunneum*. Four illustrations (Jordan and Gilbert, *op. cit.*; Evermann and Goldsborough, 1907, Bull. U. S. Bur. Fish., *26:* 219–360; Townsend and Nichols, *op. cit.*; and Clemens and Wilby, 1949, Bull. Fish. Res. Bd. Can. *68:* 368) have appeared over the name, *Bothrocara mollis*, but each of these actually depicts *B. brunneum*. Clemens and Wilby (*ibid.*) give diagnostic characters for *B. brunneum*, but a correct record for *B. molle*, under the title, *Bothrocara mollis*. The two species are distinct, and may be distinguished by the above key. David and Hill (1939, Bull. S. Calif. Acad. Sci., *37*(3): 141–145) recorded 20 specimens of *B. molle* from Le Conte Glacier, Alaska. Dr. Hill kindly made seven of them (Los Angeles Museum A375) available, and they proved to be *B. pusillum*. He has assured the writer that the other specimens are similar to those sent. Chapman (1940, Occ. Pap. B. C. Mus., *2:* 44) recorded *B. molle* from Graham Island, B. C. Re-examination of the specimen by Hubbs and Schultz (1941, Occ. Pap. Mus. Zool. Univ. Mich., *431:* 31), however, showed it to be *Lycodapus mandibularis*.

Bothrocara brunneum (Bean), 1891.—Distribution: Coronado Islands, Calif., to Olyutorski Bay and Sakhalin Island, U. S. S. R., in 109 to 756 fm. The confusion of this species with *B. molle* has been discussed above.

Lycodapus fierasfer Gilbert, 1891.—Distribution: Panama to Umnak Island, Alaska. Alverson (1951, *Copeia*, (1): 86) recorded *L. mandibularis* from Ratz Point, Clarence Strait, Alaska, 220 fm., March 27, 1950. These specimens could not be located. Two specimens of *L. fierasfer* labeled *L. mandibularis*, Luck Point, Clarence Strait, Alaska, 210 fm., March 25, 1950, were found, however (UWCF 6876). The U. S. Fish and Wildlife Service vessel *John N. Cobb*, which made the collections, did not make any drags on March 27, but a drag was made at Ratz Point on March 26. *L. grossidens* may be synonymous with *L. fierasfer*. Gilbert (*op. cit.*) defined the former on the basis of its pectoral counts (five vs. eight for *L.*

fierasfer) and its larger teeth. The writer has obtained pectoral counts from six to eight for *L. fierasfer*. Mr. R. H. Kanazawa obtained counts from seven to eight on the holotype (USNM 75824) and three paratypes (USNM 135596) of *L. grossidens* and the writer obtained a count of eight on one paratype (SU 25634). Three relatively recent specimens in good condition (UWCF 6876, 10580) are catalogued as *L. fierasfer*, and hundreds more in the same collection as *L. mandibularis*. Most of these specimens exhibit the large, curved, canine-like teeth which Gilbert (*ibid.*) stated to be characteristic of *L. grossidens*. Of course the specimens catalogued as *L. fierasfer* may actually be *L. grossidens*, but those catalogued as *L. mandibularis* are definitely distinct. Probably these fragile, canine-like teeth are characteristic of both *L. fierasfer* and *L. mandibularis*, and their absence in some specimens is due to damage or their presence in others is associated with sex, season, or maturity. More specimens will be required to determine the status of these fish, so they are left separate in this paper.

Lycodapus mandibularis Gilbert, 1915.—Distribution: Monterey Bay, Calif., and Graham Island, B. C. The southern California record of Clemens and Wilby (*op. cit.*) cannot be verified. The record of Alverson (*op. cit.*) for this species in Clarence Strait, Alaska, is doubtful for reasons discussed under *L. fierasfer*. The study material included two specimens captured in a 1-meter plankton net in Puget Sound near Seattle in 1951, received from Dr. A. C. DeLacy, and over 500 specimens captured in a 6-foot midwater trawl in Puget Sound from East Pass to Possession Sound in 1957, received from Mr. W. I. Aron. Most of the latter were captured in about 20 night hauls 25 to 75 fm. below the surface. This population apparently does not extend south of Point Defiance nor into Admiralty Inlet, though other populations may exist in unexplored areas nearby. These specimens are all deposited in the University of Washington collection.—WILLIAM H. BAYLIFF, *Inter-American Tropical Tuna Commission, P. O. Box 3665, Balboa, Canal Zone.*

ARTIFICIAL PRODUCTION OF AN INTERGENERIC ATHERINID FISH HYBRID.—Many workers have reported artificial production of F_1 generations of interspecific and intergeneric hybrids among fishes (Buss and Wright, 1958, Trans. Am. Fish. Soc., 87: 172–181, and others, for salmonids; Suzuki, 1957, Japanese Jour. Ichthy., 5: 114–117, for cyprinids; Suzuki, 1957, Japanese Jour. Gen., 32: 8–14, and others, for cobitids; Newman, 1914, Jour. Exptl. Zool., 16: 447–499; Ötzan, 1954, Rev. Fac. Sci. Univ. Istanbul, Ser. B, 19: 245–280, pls. i–vi; and Hubbs and Drewry, *in press*, Publ. Inst. Mar. Sci. Univ. Texas, 5 (2), for cyprinodontids; Hubbs, 1955, Syst. Zool., 4: 1–20; and Clark, Aronson, and Gordon, 1954, Bull. Am. Mus. Nat. Hist., 103: 141–225, pls. 1–9, for poeciliids; Hubbs and Hubbs, 1932, Pap. Mich. Acad. Sci., Arts, Letters, 15: 427–437, for centrarchids; Hubbs and Strawn, 1957, Jour. Exptl. Zool., 134: 33–62, for percids; Rubinoff and Shaw, 1958, Biol. Bull., 115 (2): 361, for atherinids; and Moenkhaus, 1910, Proc. Indiana Acad. Sci., 1910: 353–393, for assorted fishes). The centrarchid hybrids include some between species previously assigned to different genera, but now regarded as congeneric. Hubbs (1955, Syst. Zool., 4: 120) reported natural intergeneric hybrids between members of all of the above groups except cobitids, which do not occur in the region he discussed, and atherinids. The two known natural atherinid hybrids are (1) *Menidia menidia* (Linnaeus) by *Menidia beryllina* (Cope) (Gosline, 1948, Evolution, 2: 306–313), the same combination that Rubinoff and Shaw produced in the laboratory, and (2) *Chirostoma chapalae* Jordan and Snyder by *C. consocium* Jordan and Hubbs (Jordan and Hubbs, 1919, Stanford Univ. Publ. Univ. Ser., No. 40: 1–87, pls. 1-12). We herein record an artificially induced third atherinid hybrid combination, *Menidia beryllina* ♀ by *Membras martinica* (Valenciennes) ♂, which is the first to be reported between recognized genera.

On August 11, 1958 we stripped eggs from a female *Menidia beryllina* and spread sperm from *Membras martinica* over the eggs. The parents were collected in the vicinity of Port Aransas, Texas. Fertilization occurred in a few eggs and five developed pigmented eyes. Four of these hatched in four days at about 29°C. and 30 ppt. salinity. These fish were normal larvae and died (of starvation) five days after hatching together with the *Menidia beryllina* controls. Although it is now possible to rear atherines in the laboratory (Rubinoff, 1958, *Copeia*: 146–147), we were not successful with either the hybrids or the controls, perhaps due to the warmer temperatures and resulting high metabolic requirements. As the hybrids decomposed almost immediately after death, it was not possible to ascertain if they were morphologically intermediate between the parental species. They did not show high embryonic mortality and other traits of gynogenetic development (Moore, 1955, Adv. Gen. 7: 139–182) or embryos in which the paternal chromatin is eliminated or inactive (Hertwig, 1935, Handbuch der Vererbungswiss., 2(B): i–iv

+ 1–140). Moreover, these hybrids hatched one or two days before the *Menidia* controls. As ripe *Membras* females were not available, no control was made on that species. Hybrid developmental rates typically differ from that of controls when those of the controls are dissimilar from each other and embryos with primarily maternal inheritance have maternal developmental rates. Thereby, we feel we are safe in assuming that we are dealing with hybrids.

Our success with intergeneric atherinid hybrids is not surprising as atherinid by cyprinodontid hybrids have been produced previously (Clark and Moulton, 1949, *Copeia*: 152–154). Lack of apparent deformities in the intergeneric hybrids conforms to results with other intergeneric hybrids and differs from that of workers studying hybrids between parents belonging to different families or subfamilies (Hubbs and Drewry, *op. cit.*).

This work was supported by NSF research grant 2214 and carried out at The Institute of Marine Science, The University of Texas. We wish to thank the director, Dr. H. T. Odum, and all of the staff for their interest in and cooperation with our studies.—CLARK HUBBS AND GEORGE E. DREWRY, *The University of Texas, Austin, Texas.*

REVIEWS AND COMMENTS

A FIELD GUIDE TO REPTILES AND AMPHIBIANS. By Roger Conant. Houghton Mifflin Co., Boston, Mass., 1958: 366 pp. Forty plates, 24 in color, plus numerous line drawings illustrating specific diagnostic features. $3.95.—The only excuse I can think of for reviewing this book in COPEIA is for the benefit of our foreign members. Almost everyone else in the American Society of Ichthyologists and Herpetologists has seen all or part of it in the making and has been waiting to see it come off the press.

As a reviewer I feel that after praising the excellence of this newest addition to the Field Guide series I should then say, "but..." However, there I am stuck; there are no "buts".

For the first time, anyone in the eastern United States interested in knowing what snake, frog, salamander, or turtle he is observing, or has just captured, can find the answer in one book. Previously there have been books on each of the five major groups, and for the beginning student the total cost was quite large, especially if all he wanted to know was the name of a particular animal. Naturally this book does not take the place of five books. The compact form of the Field Guide series does not permit space for all of the discussions of life history, variations, and other information presented in books that treat only one group. However, the amount of information about habitat preferences and behavior that is included in this book is surprising.

The Conants are well known as a writer-illustrator team. In addition to which they are also two of the most delightful and persistent birdpickers in the field. As a result, this Field Guide is not just up-to-date, it is well ahead of the published literature. Although they give credit to the many individuals who cooperated by supplying specimens and information, they made no mention of their own vast amount of correspondence, interviews and field work which went into the obtaining and verifying of every detail in this book. Every herpetologist working on either taxonomy or distribution was queried on his specialty. Whether they were after a rare species to photograph or an elusive fact, they went after it with the perseverance of the F.B.I.

The book is arranged in the familiar format of the Peterson Field Guide series, plus much useful information on collecting, care of captive specimens, and the treatment of snake bite.

The 248 distribution maps deserve special mention; although small, they are the most detailed distribution maps presently available for the species included in this book.

After years of waiting, the newest addition to the Field Guide Series does not come as an anticlimax; it is a book definitely worth waiting for.—NEIL D. RICHMOND, *Carnegie Museum, Pittsburgh, Pennsylvania.*

MARINE ECOLOGY. By Hilary B. Moore. New York, John Wiley & Sons, Inc. London, Chapman & Hall, Ltd. 1958. $9.50.—After a discussion of physical, chemical and biological environmental factors the author discusses marine habitats, and at greater length the organisms of the different habitats. In most chapters, fishes

are but occasionally referred to; the chapter on "inshore pelagic organisms" however is made up exclusively from facts of fishery biology. The total number of fish species cited is under thirty, and the space devoted to their treatment less than one-tenth of the volume. But as a precise and instructive treatise on current questions of marine ecology the book is to be highly recommended to everybody interested in seeing the results of ichthyology and fishery biology integrated into the study of more general problems of biology.—GERD VON WAHLERT, *Museum of Comparative Zoology, Cambridge, Massachusetts.*

PROVISIONAL KEYS TO THE FISHES OF ALASKA, By Norman J. Wilimovsky. Fisheries Research Laboratory, U. S. Fish & Wildlife Service, P. O. Box 2021, Juneau, Alaska. May 1958. 113 pages.—It is a pleasant happenstance that Wilimovsky's keys to the fishes should appear the same year Alaska shall become a state. Hitherto it has been necessary to turn to works dealing with the Soviet Far East and Canada to "run down" Alaskan material because nothing inclusive other than faunal listings has been published on fishes from Alaska south of Bering Strait since 1907. The keys cover 398 species in 76 families. Not all of the species listed have been found in Alaskan waters, and appropriate notations appear for many of these; in some cases, however, the reviewer has not seen any published locality records and feels that Wilimovsky should have documented each of these additions to the fauna—e.g. *Eumicrotremus derjugini, Anarhichas denticulatus.* Statements regarding geographic range are fairly detailed for some species (e.g. *Dallia pectoralis*) but so terse for others as to be misleading—e.g. *Triglops pingeli* is indicated for "Bering Sea-Washington" though originally described from Greenland material, and the species is actually circumpolar with extensive distributions in both the North Atlantic and North Pacific oceans. Perhaps it would have been best to limit the range designations to actual occurrence in Alaskan waters. Notwithstanding the foregoing minor criticisms, Wilimovsky's keys should prove a real aid in identifying Alaskan material; it is in the hands of the compiler of faunal lists that they may prove dangerous.

An appendix of seven pages is devoted to instructions for the making, preserving and documenting of fish collections. Two statements are made which are debatable. It is implied that fishes having swimbladders rise to the surface when poisoned by rotenone; it has been the reviewer's experience that many fishes with swimbladders sink to the bottom when poisoned. Wilimovsky claims most types of rotenone do not kill invertebrates, whereas the reviewer has witnessed widespread destruction of mollusks, echinoderms and certain crustaceans when emulsifiable rotenone was used to collect in warm waters. Rotenone fortified with sulfur compounds appears to be even more destructive to the invertebrate fauna. The reviewer has mixed feelings regarding the widespread practice of poisoning to obtain fish collections.—VLADIMIR WALTERS, *The American Museum of Natural History, New York 24, N. Y.*

A CHECKLIST OF THE FRESHWATER FISHES OF CANADA AND ALASKA. By W. B. Scott. Royal Ontario Museum, Division of Zoology and Palaeontology. February 1958. 30 pages. 35 cents.—(No review is felt necessary)

A LIST OF FLORIDA FISHES AND THEIR DISTRIBUTION. By J. C. Briggs. Bull. Florida State Museum, Biol. Sci., vol. 2, no. 8, pp. 221–318, 3 figs. $1.29.—This is the only work available which lists the fishes known from or likely to be found in Florida waters. The size of the fauna is most impressive, containing 1,120 species. Briggs is to be congratulated for having undertaken and completing the task. True, there are many items which may be criticized but the list should focus attention on what the systematic problems are. In the meanwhile, it shall be a most useful guide for persons not well versed in the Florida fauna.

Pages 235 through 246 are devoted to a discussion of the distributions of Florida fishes. Table 3 is a listing of endemic Florida species and subspecies which total 85; some are endemics in name only, not distinct from more widely ranging forms, while others are known only from the original descriptions and may not be endemics; the actual number of endemics may not exceed half the forms listed. The reviewer cannot endorse the section on local distributions of shore and freshwater fishes, since he has a different viewpoint which will soon be in press.—VLADIMIR WALTERS, *The American Museum of Natural History, New York 24, N. Y.*

KEY TO THE NAMES OF BRITISH FISHES, MAMMALS, AMPHIBIANS AND REPTILES. By R. D. Macleod. Sir Isaac Pitman & Sons, Ltd., London. viii + 71 pp. 12/6.—A useful little publication, in which one may learn the derivations of both the common and the scientific names of British vertebrates other than birds.

THE SNAKES OF ONTARIO. By E. B. S. Logier. University of Toronto Press, 1958: x

+ 91 pp., illustrated. $4.95.—The herpetofauna of Ontario is not noted for its richness of its exotic qualities. It is pleasant, however, to have a portion of this fauna so well presented as in this book. Though a book strictly for the amateur, it is distinguished by clarity and simplicity without condescension in the introductory section on the biology of snakes. The systematic part has very good illustrations—one is in color and there is a colored frontispiece—and there are maps for each species showing primarily the distribution in Ontario, but with a small inset showing the total range of the species. Technical names are cited only in an appendix. There is a modest bibliography, a key, a glossary, an index and a very lucid, careful and detailed discussion of snake bite including instructions to the physician.

EDITORIAL NOTES AND NEWS

JOHN TREADWELL NICHOLS
1883–1958

The passing of John Treadwell Nichols on November 10, 1958, removed one of our cherished friends, an able founder, sponsor, and Honorary President of the American Society of Ichthyologists and Herpetologists. In the early days of this organization it was he with ever ready and sustained interest who kept the course and the trend of the new venture. This society was the first of its kind to develop a special interest in ichthyology and herpetology. Necessarily, it started in a small way with a single sheet called *Copeia*, setting forth short articles as notes, records, observations, etc. It was named *Copeia* in memory of Professor Edward Drinker Cope. He was so chosen as representing the most distinguished American accomplished in both ichthyology and herpetology, in both the systematic and faunal aspects of these sciences. By sustaining the interest over a decade or more, Mr. Nichols performed a highly valued service. In addition his efforts in procuring articles, and in their selection, presentation, diversity, etc. showed good judgment. Gradually *Copeia* emerged to become the present successful publication of today.

John Treadwell Nichols was born at Jamaica Plain, Massachusetts, June 11, 1883, and died in Garden City, Long Island, New York, November 10, 1958, at 75 years of age. He was an assistant in the Department of Mammals, in the American Museum of Natural History, New York City, during 1907–1908, and 1913–1919 was an Assistant Curator of Recent Fishes; in 1920, he became Associate Curator, and served as Curator from 1927 to 1952 when he retired. His first paper on fishes appeared in 1908, and like many of his contributions which followed were of but several pages each. They were published mainly in *Copeia*, The *Bulletin of the American Museum of Natural History*, and the *American Museum Novitates*.

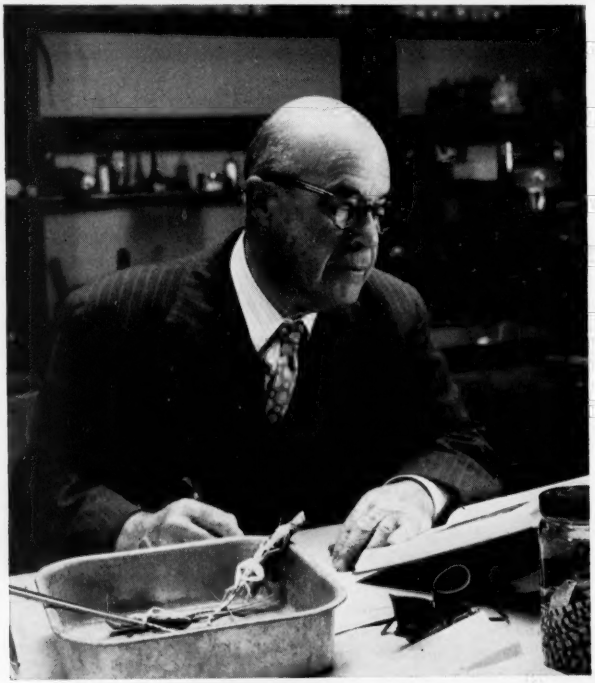
His first pretentious work, shared with Ludlow Griscom, was the Results of the American Museum of Natural History Congo Expedition (1909–15) on fresh water fishes. The collection studied embraced close to 6000 fishes, representing 234 species. Of these four genera and 29 species were described for the first time. The work also included interesting paragraphs entitled "Speculations concerning the Origin of the African Ichthyfauna" and several color plates.

His major work "The Fresh-water Fishes of China" published as a contribution to the natural history of Central Asia by the American Museum of Natural History in 1943, comprises 222 pages, 10 colored plates representing 36 species, and 143 figures of species and subspecies. The introduction comprises a short, though informative, discussion of several characters; the possible relations of the predominating carp-like fishes and their allies (Ostariophysi). The greater part of this work is the systematic account, which gives definitions of the families, genera, species and subspecies. The keys to the species are quite informative and helpful.

John Treadwell Nichols was rather tall in appearance, striking, ever affable, generous, greatly interesting and possessed of a deep sense of humor and comprehension. Visits to the American Museum of Natural History were always enriched by his warm welcome. Similarly, his visits to Philadelphia were always pleasant occasions for us. Seldom have we had the privilege to meet with a man of his worth, who so successfully effaced himself and shouldered at the same time the responsibilities of his commitments. HENRY W. FOWLER, *The Academy of Natural Sciences of Philadelphia.*

JOSEPH RICHARD SLEVIN
1881–1957

When Joseph R. Slevin, Curator of the Department of Herpetology at the California Academy of Sciences, died suddenly on February 15, 1957, he had been a member of the Academy's staff almost 53 years. An indefatigable worker and a man of rugged constitution, he was active to the end, and indeed scarcely knew a day's illness till his seventy-fifth year.



Joseph R. Slevin, July, 1953

Mr. Slevin was born in San Francisco, September 13, 1881. His father was Thomas E. Slevin, a man of considerable learning, a member of the California Academy of Sciences, and an enthusiastic amateur ornithologist, who accumulated a private collection of about 3,000 birds. Joseph accordingly grew up in an environment conducive to an interest in science. As a boy he sometimes went with his father to visit George Davidson, a past president of the Academy, and one of the most distinguished scientists of his day.

Joseph was educated at St. Ignatius High School in San Francisco and at St. Mary's College in Kansas. Then a thirst for travel and adventure took him to sea. By the time he was 23 he had served an enlistment in the U. S. Navy and had made some 20 voyages with the Oceanic Steamship Company.

Then came the opportunity to combine his love of the sea with his interest in science. The Academy was planning an expedition to the Galapagos Islands and needed a crew that could both sail a ship and do scientific work. Slevin was obviously qualified as a sailor, and his family background gave promise that he would make a good collector. He was given an intensive course in collecting reptiles by Dr. John Van Denburgh, then curator of Herpetology, and on June 28, 1905, he sailed for the Galapagos aboard the schooner *Academy*. His first employment at the Academy was in May, 1904, so he had a year of training with Van Denburgh before the expedition sailed.

The Galapagos expedition was away 17 months. While it was gone the Academy's museum was completely destroyed in the earthquake and fire of 1906. But when the expedition returned to San Francisco on November 29, 1906, the Acad-

emy—which did not have much else—had the world's foremost collection of Galapagos fauna and flora.

Mr. Slevin returned to the Academy as Van Denburgh's assistant, and in 1928 became curator of the department.

In addition to being an authority on the Galapagos Islands, Slevin collected extensively in Lower California, Australia, Central America, and elsewhere. His bibliography of scientific publications includes 58 titles[1], the last one published in September, 1956. At the time of his death he had two books in manuscript, one a history of exploration in the Galapagos, the other a popular handbook of reptiles. He also had in preparation a manuscript on lizards collected on his three expeditions to Australia, which will be completed and published.

Mr. Slevin served as a submarine officer in World War I, and tried hard to get back into the Navy in World War II, but was rejected on account of his age. Thereupon he did the next best thing, and worked almost literally day and night in the Academy's instrument shop on contract work for the U. S. Navy.

Mr. Slevin was a man of extraordinary character and devotion to duty. He had a deep loyalty to the Academy, and placed the welfare of the institution above every personal consideration. No sacrifice was too great, no service too humble. He was unassuming, quiet spoken, completely undemonstrative. But those who came to know him learned that they could have no finer friend. —R. C. MILLER, *California Academy of Sciences, San Francisco.*

ALVIN SEALE
1871–1958

Alvin Seale, ichthyologist, field naturalist, aquarium expert, adventurer, explorer, soldier of fortune and one of the last of David Starr Jordan's disciples, died at his home in Corallitos, California, July 28, 1958, aged 87 years, 20 days.

He was born on an Indiana farm of English Quaker parents and throughout his long life exemplified their high moral principles. His first adventure was to the Florida Everglades in 1884. His second was riding his bicycle from Indiana to Stanford University to study fishes with David Starr Jordan.

As one of the leading students in zoology he should have graduated in 1896 but he was an unusual and individualistic student. Prolonged field trips cut deeply into class room work. In the spring of 1896 Dr. Jordan selected N. B. Scofield and Alvin Seale to go to the mouth of the Mackenzie River, British Arctic America, to find out if salmon were there. This was Seale's first trip to Alaska. Another year he made a fine collection of sea birds from California to Alaska for the British Museum. In 1898 his roommate Morrison induced him to join the gold rush to the Klondike. Morrison "struck it rich" but Seale only studied mammals, birds, fishes and called it "an exciting year."

When school opened in the fall of 1899, Seale was a senior but left to be field naturalist for the Bishop Museum of Honolulu. In 1900 he made the first zoological survey of Guam, returning via Manila, Hong Kong, Shanghai, and Japan. After that until September, 1903, he was collecting in Polynesia. The Society Islands, Tuamotu Archipelago, Marquesas, Gambier, Austral, Cook and Samoan Islands were explored. Then New Zealand, Australia (several times), the New Hebrides, and the Solomon Islands were next. Those South Sea years were rich in rare experiences. A few of them are told in his privately printed book, "Quest for the Golden Cloak."

He entered Stanford again in the fall of 1904 and graduated in May, 1905, thirteen years after first entering. During those 13 years he had learned more about Polynesia, its fishes and fisheries, than anyone else in the United States and had published several important papers.

The next adventure was to go, at Dr. Jordan's request, in 1905, to the Texas coast to get cyprinodonts, take them to Honolulu, and see if they would eat mosquito larvae. One of them, *Gambusia patruelis*, was an eager eater of mosquito larvae. In the next two decades this "mosquito fish" was distributed over much of the world to combat the mosquito plague.

In 1906 Alvin Seale had charge of the Anna Alexander Expedition to Alaska. Bears, moose, big horn sheep, and other animals, were collected for the Alexander Museum of Vertebrate Zoology, University of California. While the rest of us were nearly always tied down and unable to leave, Seale was always footloose and carefree, always turning up at the right time to undertake a new adventure, well paid and richer in experience. That is why I called him in those days a soldier of fortune.

In February, 1907, President Theodore Roosevelt appointed him fishery expert for the Philippine government. His next 10 years were spent in this attractive position with the Philippine Bureau of Science.

During this period he (1) published on the fishery resources of the Island, the pearl, shell,

[1] A complete list of Mr. Slevin's publications appears in a paper by Slevin and Leviton, 1956, Proc. Calif. Acad. Sci., 4th Ser., vol. 28, pp. 556–559.

sponge and trepang industries, and the fishes of Borneo and Hong Kong; (2) established fishery industries and prepared laws to control them; (3) introduced carp from China to Mindaneo, bass from the United States to Baguio in Northern Luzon, mosquito fish from Honolulu to Manila; (4) drew plans for the Manila Aquarium, supervised its construction and made it outstanding for the exhibit of tropical reef fishes. He visited Formosa and made several trips to Borneo, Hong Kong, China, and Japan.

Mr. Seale became the ichthyologist, Museum of Comparative Zoology at Harvard, in 1917 and retired to his ranch near Santa Cruz, California, in 1920. In 1921 Dr. B. W. Evermann induced him to revise plans for the Steinhart Aquarium, supervise its construction, and become its superintendent. He remained 20 years, resigning when he was 70. In 1929 he revisited Samoa to get aquarium fishes. In 1931–32 he was in charge of the scientific staff of the G. Allan Hancock Expedition to the Galapagos Islands. In 1935 and in 1939 came trips to the Hawaiian Islands to get aquarium fishes. In 1938 he and his wife made a trip around the world. In 1941 they visited the Yukon, Fairbanks, Mt. McKinley, and Seward, Alaska.

Mr. Seale was author or joint author of 162 books and papers. He was the most successful person I have ever met in transporting live fish from a cool climate to the tropics or from high altitudes to sea level. Only those who have had experience in such difficult matters can appreciate his phenomenal skill without any of the aids which now reduce the risks to almost nothing.

Alvin Seale was twice married. His first wife, Ethel Prouty, whom he married in 1908, died in 1936. In 1938 he married Mrs. Jessie Frapwell, who survives him.

For many years the hobby of the Seales was collecting books on the South Seas. Finally this library of 1300 volumes was one of the most complete in existence. In 1936 Mr. Seale donated this valuable collection to the public library of Pacific Grove, California, as a memorial to his first wife. His valuable professional library was donated to the California Academy of Sciences.

Mr. Seale, smiling and always pleasant and of noble character, made friends wherever he went and held them for life. After his retirement the Seales lived in their lovely home in Corallitos. Here a stream of friends from all over the United States and the countries bordering the Pacific and from its islands, sought his company and advice, as did also many young people, in whom he took great interest. The hospitality of the Seales became legendary and to be invited to their holiday house parties was a great privilege. I pay tribute to Alvin Seale as a brother scientist and as a man who was a treasure to his family and friends. The San Francisco Aquarium Society, the California Academy of Sciences, and the Ichthyologists and Herpetologists have each lost a great friend.—ALBERT W. HERRE, *College of Fisheries, University of Washington, Stanford University, Emeritus*

A. Vedel Tåning

DR. A. VEDEL TÅNING, Honorary Foreign Member, died September 26, 1958, in Copenhagen. Dr. Tåning was director of the Carlsberg Laboratory, the Dana Collections, and the Danish Fisheries Research Station at Charlottenlund Slot, Denmark. He was well known for his researches on variation in fishes, particularly for his critical experiments on the effects of temperatures on meristic characters, and for his studies on the systematics of myctophids and other pelagic fishes.

New Editor-in-Chief

EFFECTIVE with this issue PHILIP W. SMITH, Illinois Natural History Survey, Natural Resources Building, Urbana, Illinois, assumes temporary editorship of *Copeia*, replacing DR. FRED R. CAGLE of Tulane University. All manuscripts and communications should be adressed henceforth to Urbana. Probably no member of ASIH, except the present Editor-in-Chief, can realize the tremendous amount of time and energy poured into the production of *Copeia* by DR. CAGLE and his staff at Tulane. The Society owes a great debt to FRED CAGLE for his long tenure and unstinting efforts to improve the quality of our journal. The present Editor wishes to express his personal gratitude to DR. CAGLE, to PRESIDENT BAILEY, and to SECRETARY CONANT, who have already given him gratifying and heartwarming cooperation. Nevertheless, the new Editor is at present in a difficult position and urges that all members re-read "Suggestions for Authors Publishing in *Copeia*" which appeared in *Copeia* 1958 (1): 67–69, follow the directions outlined by DR. CAGLE, and carefully edit any manuscripts before submitting them to *Copeia*. The Editorial Board particularly insists upon compliance with Suggestions 4, 9–11, 15, 18, 20, 23, 24, 27, 28, and 39 inasmuch as disregard of these greatly increases the burden of the Editor.

News Notes

WILLIAM E. DUELLMAN, Wayne State University, is initiating a three-year study on the distribution and systematics of the hylid frogs of Middle America;

his work is being supporated by a grant from the National Science Foundation.

DR. JAMES A. PETERS, Brown University, has received a Fulbright Lectureship at the Universidad Central, Quito, Ecuador for the school year 1958–1959. He will lecture in biology and continue his researches on the herptofauna of Ecuador. His address during his stay in Ecuador is: c/o Commision Fulbright, Apartado 538, Quito, Ecuador.

During the XVth International Congress of Zoology in London, July, 1958, a dinner party of interest to the ASIH was held, for it was attended by the herpetologists at the meetings. Organized by L. D. Brongersma, it was attended by: J. C. Battersby, L. D. Brongersma, J. Condit, G. F. De Witte, A. G. C. Grandison, T. Hunt, J. Iselt, M. LaMotte, R. Laurent, R. Mertens, J. A. Peters, J. Roze, R. Stebbins, H. Wermuth, as well as wives and families.

DR. ARNOLD B. GROBMAN, Director of the Florida State Museum, has been given a leave of absence from the University of Florida in order to accept appointment as director of an educational commission in the biological sciences.

DR. GROBMAN will head the Biological Sciences Curriculum Study organized by the American Institute of Biological Sciences. Headquarters for the study will be on the campus of the University of Colorado with the first formal meeting set for February 5–8.

The group will investigate course content and teaching procedures in the biological sciences at all levels of educational institutions from elementary schools through universities and professional schools. Study will also be made of other educational media such as museums, films, magazines, and television.

DR. HENRY S. FITCH, Department of Zoology, University of Kansas, is completing a ten-year field study of the copperhead in northeastern Kansas, and desires comparative data from other parts of the range on any phase of the species' ecology. Notes concerning habitat, food habits, sex ratio, reproduction, etc., that are not going to be published separately, will be welcome and all cooperators will, of course, be given full credit for their contributions.

Stanford University

FOUR Stanford ichthyologists are engaged in fish studies in the Antarctic, supported by the O.N.R. and the National Science Foundation. DR. D. E. WOHLSCHLAG, accompanied by J. H. DEARBORN, left for McMurdo Sound in October, 1958, for a preliminary examination of the fishes and the shore fauna, and to begin investigations on fish growth and ecology. DR. WOHLSCHLAG returns in February, but MR. DEARBORN is wintering in Antarctica. J. C. TYLER and H. H. DE WITT, two students of PROF. MYERS, left in October for Antarctic cruises on different U. S. Navy icebreakers, for fish collecting and preliminary studies on fish ecology and especially on the blood of the Chaenichthyidae, an Antarctic fish group lacking red blood cells.

PROF. CURT KOSSWIG, Director of the Zoological Institute and Museum of the University of Hamburg and Professor of Zoology at the University of Istanbul, visited PROF. MYERS on October 19–21, and lectured at Stanford on the remarkable speciation problems in Turkish cypinodont fishes.

The Russian Oceanographic Ship *Vityaz* spent five days at San Francisco (December 17–22, 1958). Oceanographers and marine biologists from many west coast institutions, as well as the general public, were invited aboard. The ichthyological unit of the *Vityaz*, including the unit leader, MR. NIKOLAI VASILYOVICH PARIN, and two junior scientific workers, MESDAMES NINA VASILEVNA KHRAPKOVA and VALENTINA ALEKSANDROVNA MUKHACHEVA, accompanied by a photographer, VALENTIN NIKOLAEVICH NARTSISSOV, were the guests of Stanford University and PROF. G. S. MYERS on December 19. After briefly visiting the fish department of the California Academy of Sciences and the Steinhart Aquarium, PROF. MYERS drove the group to Stanford, where they attended a luncheon of the Biology Department faculty. MR. PARIN then spent the afternoon studying flying fishes at the Stanford Natural History Museum. Much valuable Pacific flying-fish material was lent to MR. PARIN by DR. R. R. ROFEN, Director of the George Vanderbilt Foundation of Stanford, who acted as co-host to the group. After a dinner with the Stanford ichthyological group, the Russian visitors were returned to their ship. It is believed that this group comprised the first Soviet Russian ichthyologists ever to visit and study in an ichthyological laboratory in the United States.

Earlier in December, the new training ship of the Shimonoseki College of Fisheries visited San Francisco, and many local biologists were welcomed aboard. The leader, DR. REIZO ISHIYAMA, spoke before a "Stanford Fischverein" meeting at the Steinhart Aquarium on the classification and caudal electric organs of skates (Rajidae) and later visited Stanford and re-identified many of the Japanese skates in the Museum collection.

Collaboration in herpetology between DR. W. C. BROWN, Research Associate at the Stanford Natural History Museum, and Silliman University, Dumaguete, P.I., is continuing actively. Fur-

ther large Philippine collections have recently been received.

PROF. R. L. BOLIN of Stanford's Hopkins Marine Station returned in January with MRS. BOLIN after nearly a year of ichthyological work with the Hong Kong Fisheries Department. Large collections from the Hong Kong area were obtained with the view of writing a manual of Hong Kong fishes. On his return trip, PROF. BOLIN was able to make fish collections in the Solomon Islands and visit Sydney, Australia, where he studied lantern fish types.

University of Oklahoma

THE University of Oklahoma Biological Station announces a new course in Animal Behavior (Zoology 309) to be offered during the 1959 summer session. The field and laboratory phases of this course will emphasize the local fauna. This will be a three credit hour course designed for upperclass and graduate students.

The Biological Station is situated on Lake Texoma in south-central Oklahoma. There is a rich vertebrate and invertebrate fauna in this area available for behavior studies. Research programs in animal behavior by the staff, graduate students and private investigators at the Biological Station have involved all classes of vertebrates and some invertebrates. The necessary facilities and equipment for field and controlled behavior studies are available or can be obtained.

Persons interested in this course or in the Biological Station should write to DR. CARL D. RIGGS, *Director, University of Oklahoma Biological Station, Norman, Oklahoma.*

Southeastern Division

THE Southeastern Division of the ASIH will hold its ninth annual meeting in conjunction with the Association of Southern Biologists at the University of Tennessee, Knoxville, Tennessee, April 16–18. Members from outside the southeast are cordially invited to attend and participate in the meetings. Titles of papers may be sent to DR. E. E. BROWN, *Biology Department, Davidson College, Davidson, North Carolina.*

Philadelphia Herpetological Society

THE January, 1959, issue of the Bulletin of the Philadelphia Herpetological Society contains a survey of the amateur and professional herpetological societies of the world. The survey includes such pertinent information as mailing addresses, officers, activities, etc.

The PHS Bulletin, now in its seventh year, is a bimonthly newsletter. It circulates internationally. Single copies are available at 25 cents each. Subscription is $1.50/year in the U. S.; foreign rate, $3.00. Address all correspondence to the Editor, BARRY ROTHMAN, *PHS, 7036 Rising Sun Avenue, Philadelphia 11, Pennsylvania.*

The Karl P. Schmidt Fund

THE KARL P. SCHMIDT Fund has modest sums available to assist persons wishing to study at the Chicago Natural History Museum. Grants will be made for study in any of the four fields encompassed by the museum: anthropology (with a natural history orientation), botany, geology (including paleontology), and zoology. An applicant should describe the study proposed in brief terms, state the length of time he wishes to study at the museum and the amount of money needed, and name one reference.

Applications should be mailed to: CHAIRMAN, THE KARL P. SCHMIDT FUND, c/o *Chicago Natural History Museum, Roosevelt Road, and Lake Shore Drive, Chicago 5, Illinois.*

Correction

IN Figure 1 of the paper on the fossil turtles of the Friesenhahn Cave (*Copeia* 1956 (3): 162–71) the means of some of the ratios fall outside of the observed range. In comparing the published ratios with the originals, it has been found that the carapacial and plastral ratios have been transposed in some of the vertical columns of the publication. All of the figures published for the numbers of specimens, ranges, and means of *T. carolina* and the numbers of specimens and ranges of *T. canaliculata* are incorrect. Correction may be made in these columns by re-arranging the names of the elements. For these corrections, the column of elements should read Gular through Post L and then Vert 1 through Carp, instead of Vert 1 through Post L. These corrections apply only to the columns named above. The last seven vertical columns are correct as published.—WM. W. MILSTEAD, *Department of Biology, Texas Technological College, Lubbock, Texas.*

Protest of Fire Ant Campaign

AT the Board of Governor's Meeting in Bloomington, Indiana, last August, the Secretary was instructed to seek the advice of experts on biocides and draw up a resolution opposing the method of control of the imported fire ant. MR. CONANT was further instructed to dispatch copies to the proper authorities and to officers of other scientific societies urging them to take similar action. The resolution is published below for the benefit of ASIH

members who did not attend the Board of Governors' meeting at Indiana University.

RESOLUTION IN OPPOSITION TO THE IMPORTED FIRE ANT CONTROL CAMPAIGN—PASSED UNANIMOUSLY BY THE AMERICAN SOCIETY OF ICHTHYOLOGISTS AND HERPETOLOGISTS AT ITS ANNUAL NATIONAL MEETING HELD ON THE CAMPUS OF INDIANA UNIVERSITY, 1958

WHEREAS, the United States Department of Agriculture and associated state agencies have begun chemical treatments within an over-all area of some 27,000,000 acres of the Southeast with the hope but dubious likelihood of exterminating the imported fire ant, and

WHEREAS, much of this treatment consists of aerial distribution of heptachlor or dieldrin at 2 pounds of active ingredient per acre, which is equivalent in killing power to certain forms of fish and wildlife of up to 40 pounds of D.D.T. per acre, and

WHEREAS, it has already been demonstrated that one or two pounds of dieldrin per acre causes serious depletion of many kinds of terrestrial and aquatic life, and applications of one to five pounds per acre of the much more investigated D.D.T. are known to cause serious depletions of many kinds of invertebrates, fishes, amphibians, reptiles, and birds, and

WHEREAS, these poisons remain toxic up to three years and may be carried into waters of all types long after application, and

WHEREAS, extermination of fire ants will require treatment of all types of infested land including natural areas, and

WHEREAS, the Southeast possesses a wealth of fish and wildlife resources of incalculable commercial, recreational, and scientific value, and

WHEREAS, the Southeast also possesses hundreds of kinds of fishes, amphibians, reptiles, birds, and other animals that occur nowhere else in the world and many of these animals occupy only small areas and therefore might readily be completely exterminated, and

WHEREAS, each of these endemic animals has such great scientific and educational value that its extinction would be a tragic loss inconsistent with the aim of the American people to maintain all harmless kinds of animals insofar as humanly possible, and

WHEREAS, the imported fire ant is listed among the twenty worst insect pests by only two of the southeastern states, and recent studies have revealed that this ant rarely eats crop plants but is primarily predaceous on other insects,

THEREFORE BE IT RESOLVED that the American Society of Ichthyologists and Herpetologists, through its appropriate officers, recommend to the Secretary of Agriculture, to the Chairman of the Appropriations Committee of the U. S. Senate, and to the Chairman of the Appropriations Committee of the U. S. House of Representatives: (1) that *aerial distribution* of heptachlor, dieldrin, and equivalent poisons for extermination of fire ants or other purposes *be ceased at once* before irreparable harm is done, (2) that all applications for control of fire ants be limited to treatment of individual ant mounds by ground equipment, (3) that the Department of Agriculture and associated organizations launch intensive research designed to discover pest-control methods that will not endanger desirable native animals, whether game or nongame, (4) that thorough studies be made of the effect of current control programs on fishes, amphibians, reptiles, birds, mammals, and the types of animal life on which these depend for food, as well as the effects of these programs on organisms that are responsible for proper functioning of the soil, and (5) that all plans for future control programs be formulated only after great weight has been given to the possibility of extermination of any kinds of native plants and animals, especially animals and plants that are of extremely limited distribution: and

BE IT FURTHER RESOLVED that the American Society of Ichthyologists and Herpetologists stands ready at all times to provide any federal, state, or local government agency with information on fishes, amphibians, and reptiles that are of especial scientific significance in any given area. ATTEST: ROGER CONANT, Secretary.

39TH ANNUAL MEETING OF ASIH

The American Society of Ichthyologists and Herpetologists will hold its thirty-ninth annual meeting jointly with the Western Division of the American Association for the Advancement of Science on the San Diego State Campus from June 17 to June 21, 1959. Scripps Institute for Oceanography, San Diego Zoological Society, San Diego Society of Natural History, Naval Electronics Laboratory, and San Diego State College will co-sponsor the meetings.

Hotel headquarters will be at the U. S. Grant Hotel, between Third and Fourth on Broadway, in downtown San Diego. The airport is only one mile from the Grant Hotel and train and bus stations are only a few blocks. Requests for reservations for the Grant Hotel or for tourist accommodations in the vicinity of San Diego State should be made to MAXINE B. JONES, Director of Convention Activities, San Diego Convention and Tourist Bureau, 924 Second Avenue, San Diego 1, California.

All titles of papers, requirements for their presentations, and a 200-word abstract, must be received prior to April 1, 1959. Address to: D. L. JAMESON, Department of Zoology, San Diego State, San Diego, California.

Members driving and desiring information on collection and camping sites in Southern California should address their requests to MRS. BETTY SHOR, 2655 Ellentown Road, La Jolla, California.

The following events have been tentatively scheduled (including AAAS events of interest to ASIH members):

AAAS PROGRAM

Monday 15 June:
Evening—Symposium: Geophysical Year Report.
Tuesday 16 June:
AM and PM—Symposium: Biogeography of Baja California (SSZ).
Evening—Barbecue at Zoo. Presidential Address.

ASIH PROGRAM

Wednesday 17 June:
AM—Joint Session—Welcome and Response. Contributed Papers.
Noon—Group Photograph.
PM—Symposuim: Joint Session with American Society of Limnology and Oceanography.
Evening—Board of Governors Dinner, 6:00.
—Board of Governors Meeting, 8:00.
Thursday 18 June:
AM—Symposium: Joint Session with American Society of Limnology and Oceanography.
Symposium: Joint Session with Herpetologists League.
PM—Contributed Papers.
Evening—Ichthyological Session—Symposium.
Aquaria, Scripps Institute of Oceanography.
Herpetological Session—Symposuim.
Small group collecting trips to Desert.
Friday 19 June:
AM—Joint Session—Contributed Papers.
Business Meeting—National ASIH.
Business Meeting—Western Division ASIH.
PM—Contributed Papers.
Evening—Luau at Beach.
Saturday 20 June:
Full day field trip—Scripps vessel.
Mid-water trawl and diving dredge in San Diego Trough.
Sunday 21 June:
Full day field trip—Scripps vessel—Deep water poisoning—shallow water dredge. Trip ashore on Coronado Island for herpetological collecting.

Additional information can be obtained from DR. DAVID L. JAMESON, *San Diego State College, San Diego, California.*

COPEIA IS THE JOURNAL OF THE AMERICAN SOCIETY OF ICHTHYOLOGISTS AND HERPETOLOGISTS

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The American Society of Ichthyologists and Herpetologists is a member of the American Institute of Biological Sciences and of the Division of Biology and Agriculture, National Research Council, and is an affiliate of the American Association for the Advancement of Science. An annual contribution is made to the publication of the Zoological Record.

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ΕΡΠΕΤΟΝ